Issued June 12, 1911.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—BULLETIN 84.
HENRY S. GRAVES, Forester.

PRESERVATIVE TREATMENT OF POLES.

COMPILED BY

WILLIAM H. KEMPFER,
FOREST ASSISTANT.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., October 15, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "Preservative Treatment of Poles," compiled by William H. Kempfer, Forest Assistant, and to recommend its publication as Bulletin 84 of the Forest Service. This bulletin is compiled in part from previous publications of the Forest Service, namely, Circulars 103, "Seasoning of Telephone and Telegraph Poles," by Henry Grinnell; No. 104, "Brush and Tank Pole Treatments," by Carl G. Crawford; No. 136, "Seasoning and Preservative Treatment of Arborvitæ Poles," by C. Stowell Smith; and No. 147, "Progress in Chestnut Pole Preservation," by Howard F. Weiss. It presents, in addition, results of more recent experiments, especially those of O. T. Swan, Forest Assistant, who is also the author of the design for open-tank pole-treating plants. The inspection report contained in the Appendix was made by the compiler.

Respectfully,
Henry S. Graves,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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PRESERVATIVE TREATMENT OF POLES.

INTRODUCTION.

Users of poles in all parts of the country are alive to the necessity of obtaining increased length of service from their poles. This interest has been stimulated by the tendency toward advancing prices of forest products and apprehension with regard to the future supply. Realizing the need for more information along this line, the Forest Service a number of years ago began investigations of methods for prolonging the life of poles, and during the past four years a number of circulars [a] giving the progress of experiments have been published.

This bulletin aims to sum up the results that have already been published, and to present additional data and information gained by the more recent investigations.

GENERAL PRINCIPLES OF WOOD PRESERVATION.[b]

Except in very warm and moist climates, a pole which is placed on skids and allowed to become air dry does not decay, because it does not contain sufficient moisture to support the growth of fungi and wood-boring insects, which are the causes of decay. However, if the pole is set, that portion of it in contact with the soil will absorb moisture until conditions favorable to decay are restored. To prevent decay in timber exposed to the soil or moist air, the wood substance, which

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[a] The Bureau of Entomology also has published results of investigations of damage to forest products by insects, in which it is shown that injury to pole timber and the commercial and utilized product by wood-boring insects contributes to direct deterioration and subsequent decay, and that much of this loss can be prevented by proper methods of management and treatment with preservatives. Attention is called to the following publications: Insect Injuries to Forest Products, by A. D. Hopkins, Bureau of Entomology, Yearbook, Department of Agriculture, 1904, pp. 381 to 398. Bulletin 58, Part V, Some Insects Injurious to Forests, Insect Depredations in North American Forests and Practical Methods of Prevention and Control, by A. D. Hopkins, in charge of Forest Insect Investigations, December, 1909, pp. 64 to 67, 79 to 81, and 84. Bulletin 94, Part I, Damage to Chestnut Telephone and Telegraph Poles by Wood-boring Insects, by Thos. E. Snyder, Agent and Expert, Bureau of Entomology.

The references to insects in this bulletin are based to a large extent on information supplied by the Bureau of Entomology.

[b] For a more complete discussion of this subject, see Forest Service Bulletin 78, "Wood Preservation in the United States."

is the food of the decay-producing organisms, must be rendered incapable of supporting fungous growth. In commercial timber-treating practice this is accomplished by the injection of antiseptics.

It is not usually practicable even with the best methods of treatment, except in the case of very porous woods, to impregnate the wood throughout. The value of the treatment consists largely in creating an outer protective envelope around the untreated interior wood. The thickness necessary for this envelope to give efficient protection depends on the use to which the timber is to be put. In general, the antiseptic should penetrate deep enough to prevent exposure of the untreated wood by abrasion, checking, or other action. Since the liability of the protective zone to destruction from mechanical causes or by gradual volatilization of the oil is dependent on its thickness, or, in other words, on the quantity of preservative absorbed and the depth of penetration, it is reasonable to assume that within certain limits the added life of the timber due to treatment with a given preservative will be in approximate ratio to the amount of penetration and absorption of the preservative.

FOREST SERVICE INVESTIGATIONS.

Knowledge of the results of creosote treatment is based largely on treatments made by the pressure method, using from 8 to 12 pounds or more of creosote to the cubic foot of timber. In spite of the excellent results that have been obtained by such treatment, it has been but little used by pole consumers, except in certain parts of the South, where exceptionally rapid decay makes preservative treatment imperative. The chief hindrances to a more general adoption of creosote treatment for poles have been the high cost of the treatment and the expense of transporting the timber to a distant point for treating. The investigations of the Forest Service have, therefore, been concerned mostly with cheaper and simpler methods, and with treatments which could be applied locally without the erection of elaborate and expensive plants. Much attention has been given to the seasoning of poles, since proper seasoning not only prepares poles to receive the preservative treatment, but, under certain conditions, may be in itself a means of increasing their durability. The treating investigations proper have followed three general lines:

(1) Testing the efficiency of various wood preservatives and of applications of varying amounts.

(2) The developing of a method for impregnating the portion of a pole most subject to decay—the butt.

(3) Designing of inexpensive apparatus suited to the treatment of poles in small quantities, or in such quantities as local needs may require.

In these investigations much assistance has been received from a number of electrical companies, which have placed poles at the disposal of the Forest Service for the tests and contributed funds toward paying the cost of the investigations. The experimental poles, in most instances, have been placed in service by the companies interested, and in such a manner that durability records may be obtained from them. These records will prove a source of further information on the efficiency of the treatments.

RÉSUMÉ OF PROJECTS.

In 1902 field investigations were begun in cooperation with the American Telephone and Telegraph Company. The project as finally developed included chestnut, southern white cedar, and northern white cedar [a] poles, experiments with the first being conducted in North Carolina, New Jersey, Pennsylvania, and Maryland, with the second in North Carolina, and with the third in Michigan. Another project undertaken in cooperation with a number of pole-using companies in California,[b] included a study of the treatment of western yellow pine and western red cedar poles. Further sources of the information were afforded by treatments of lodgepole pine poles at a plant erected by the Forest Service on the Sopris National Forest at Norrie, Colo., and of loblolly pine poles at a plant designed by the Forest Service and erected by the North Louisiana Telephone Company at Winnfield, La. In addition to the tests in seasoning and treating, a number of experimental pole lines have been set, in which poles treated with various preservatives have been placed alongside of untreated ones in order that their durability might be compared.

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[a] This tree (*Thuja occidentalis*) has in earlier publications of the Forest Service been referred to under the common name of arborvitæ. It is, however, usually known by lumbermen and woodsmen generally as "white cedar." The name "white cedar" has in Forest Service publications been used to designate *Chamæcyparis thyoides*, which is also most widely known as "white cedar." This latter tree, though sometimes found as far north as southern Maine, is of commercial importance chiefly south of Delaware and New Jersey. *Thuja occidentalis*, common in the northern woods of New England, New York, and the Lake States, occurs as far south as North Carolina and Tennessee, but only in the mountains where the elevation is sufficiently great to permit northern species to thrive. To distinguish these two species without doing violence to ordinary usage, *Thuja occidentalis*, or "arborvitæ," will in the present bulletin receive the name of northern white cedar, and *Chamæcyparis thyoides* the name of southern white cedar. The western species, *Thuja plicata*, formerly designated in Forest Service publications as "giant arborvitæ," and most commonly known in the West as red cedar, will be called in the present bulletin western red cedar.

[b] The following companies contributed to the support of that project: Edison Electric Company, Home Telephone Company, Los Angeles Gas and Electric Company, Los Angeles-Pacific Railway Company, Pacific Electric Company, Pacific Gas and Electric Company, Pacific Light and Power Company, and San Joaquin Light and Power Company.

RESULTS OF SEASONING TESTS.

LOSS OF WEIGHT.

Table 1 shows in round numbers the weight lost by poles during seasoning until approximately air-dry. After the weights shown in this table have been reached, loss of moisture does not cease, but may continue at a decreasing rate for many months.

TABLE 1.—*Weight lost during seasoning of poles until approximately air-dry.*

Species.	Duration of seasoning.	Green weight per cubic foot.	Seasoned weight per cubic foot.	Green weight lost.	Total weight lost per pole.	Nominal size of poles.		Average volume of poles.
						Diameter.	Length.	
	Months.	*Pounds.*	*Pounds.*	*Per cent.*	*Pounds.*	*Inches.*	*Feet.*	*Cubic feet.*
Chestnut	4- 8	56	47	16	180	7	30	20.00
Southern white cedar	3- 8	[a] 37	26	30	228	7	30	20.76
Northern white cedar	6-12	33	25	24	141	7	30	17.62
Western red cedar	3- 5	[b] 33	25	24	219	8	40	27.34
Western yellow pine	3- 9	65	33	49	835	8	40	26.10

[a] Weight on arriving at Wilmington, N. C., after rafting down the river.
[b] Approximate weight on arriving at southern California ports after transportation by boat from Puget Sound. Some of the shipments weighed more.

The limits of seasoning given in Table 1 are such as would be feasible in commercial practice, and indicate the weight poles must reach in order that the main bulk of the water which may be gotten rid of by air seasoning shall be evaporated. This means a loss ordinarily of from 16 to 30 per cent of the original weight, amounting to from 141 to 228 pounds per pole in these tests, and for western yellow pine the enormous loss of 49 per cent, or 835 pounds per pole, occurred. Table 2 illustrates the saving in transportation charges possible through pole seasoning.

TABLE 2.—*Saving in freight charges effected by seasoning of poles.*[a]

Species.	Seasoned poles required for minimum carload of 40,000 pounds.	Total decrease in weight due to seasoning.	Saving in freight on carload lots.	
			25-cent rate.	15-cent rate.
	Number.	*Pounds.*	*Dollars.*	*Dollars.*
Chestnut	43	7,700	19.25	11.55
Southern white cedar	74	16,900	42.25	25.35
Northern white cedar	91	12,800	32.00	19.20
Western red cedar	59	12,900	32.25	19.35
Western yellow pine	46	38,400	96.00	57.60

[a] Based on sizes and weights of poles given in Table 1.

RATE OF SEASONING.

The rate at which wood seasons is dependent on many factors, most important of which are climatic and seasonal conditions. Two poles of the same species and in the same locality, but cut at different times of the year, will require different periods of time to lose equal amounts of moisture. Table 3 shows in detail the time required for poles cut at different seasons of the year to reach the degree of dryness given in Table 1.

TABLE 3.—*Time required for poles cut at different periods of the year to season to approximately air-dry weight.*

Species.	Location of test.	Time required for seasoning.			
		Spring-cut.	Summer-cut.	Autumn-cut.	Winter-cut.
		Months.	*Months.*	*Months.*	*Months.*
Chestnut	Parkton, Md	5	4	8	7
Southern white cedar	Wilmington, N. C.	3	3	8	5
Northern white cedar	Escanaba, Mich	12	9	7	6
Western red cedar	Wilmington, Cal	ab 4 c (3)	a 5 c (6)	a 3 c (7)	a 3 c (4)
Western yellow pine	Madera County, Cal	5	3	9	6

a Period of seasoning computed from time poles arrived at Wilmington three to seven months after cutting.
b Weight of spring-cut poles at termination of test, 28 pounds per cubic foot.
c Period in storage and in transit, during which time little seasoning took place.

Poles cut during the spring and summer dry rapidly and, except in the case of white cedar in the latitude of northern Michigan, reach an approximately air-dry condition before the following winter. White cedar poles cut during the spring and summer did not become air-dry until the following year, and required more time than poles cut during the autumn and winter to reach an equal degree of dryness, the autumn-cut and winter-cut poles becoming dry by the following summer. However, during the early part of this experiment the poles lay on skids in the woods, where seasoning was retarded by lack of air circulation and sunshine, and by the swampy character of the soil. In February all poles, consisting of monthly cuts from April to December, inclusive, were removed to the Escanaba yard, where conditions were much more favorable to rapid seasoning.

The irregularity in the results of the western red cedar tests was caused by the long period the poles were in storage (in water) and in transit, piled solidly on the decks of vessels, little seasoning taking place during this period.

FACTORS AFFECTING SEASONING.

The effect of the climatic conditions of different seasons of the year and of various regions in which the tests were made has already been brought out in Table 3, and is more fully shown in the detailed season-

ing tables and curves in the Appendix. Besides climatic and seasonal conditions, many other factors affect the rate of drying out of poles, among which are the following:

(1) *Method of piling.*—In the tests the poles were spread out in single layers on skids, in which form seasoning is most rapid. Seasoning will be much retarded if the poles are stacked in solid piles, and if that form of pile is used in a warm, moist climate, decay or injury by wood-boring insects is likely to follow should the poles be held for any considerable period.

(2) *Exposure.*—Seasoning is hastened by having the poles exposed to a free circulation of air. An open place free from underbrush or other rank growth should be chosen for the skidways. Shade does not seem to retard the loss of moisture, provided the circulation of air is not impeded.

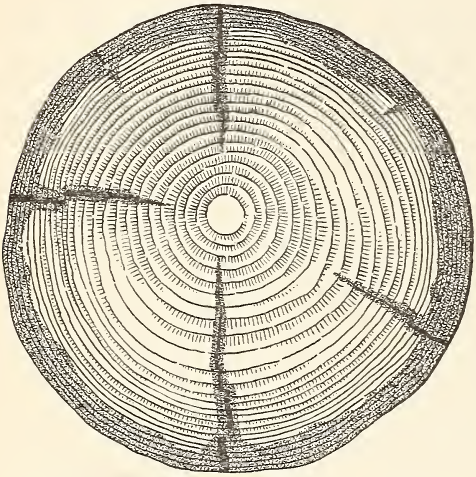

FIG. 1.—The shaded areas show progress of decay in an untreated pole. Seasoning checks, by increasing the amount of surface exposed, may hasten decay.

(3) *Soaking.*—Poles that were soaked from two to four weeks in water dried out very rapidly and in a comparatively short time reached the same degree of dryness as other poles cut at the same time and not soaked. Thereafter the seasoning of both proceeded at practically the same rate.

CHECKING.

While rapid seasoning makes it possible to realize the benefits of reduced transportation costs most quickly, it may be harmful in its effect on the timber itself. Poles seasoned rapidly check more than those seasoned slowly. Timber which seasons slowly and evenly forms numerous small checks, which close again when the wood absorbs moisture and which apparently have no detrimental effect. If, however, the poles season rapidly, wide and deep checks may be formed, which do not again close, and which not only decrease the strength of the timber, but materially hasten decay through the entrance of insects and fungi. Figure 1 shows the detrimental effect of checks that expose a very large surface to decay; they increase the rate of deterioration. Splits, windshake, and other defects of this character have a similar influence on the durability of the poles when the defects occur near the ground line.

Some species of wood, notably chestnut, have a tendency to form large checks or splits; in some cases the split opened a foot wide and extended 9 feet upward on the pole. By the use of S irons at the first indication of a tendency to such checking, serious damage may be avoided. These may be made of strap iron one-eighth inch by 1 inch, bent in the form of a letter S, from 3 to 6 inches long, and driven into the butt of the pole as shown in figure 2.

SHRINKAGE.

Hundreds of careful measurements show that the amount of shrinkage which takes place during the seasoning of poles is very slight, though this is contrary to the opinion of pole producers and consumers. The amount of shrinkage in seasoning from green to air-dry condition averaged from 0.3 to 0.5 per cent on the circumference at the ground line (6 feet from the butt), and from 0.6 to almost 1 per cent at the top. On the sizes of poles more commonly used this is equivalnet to about 0.1 or 0.2 of an inch in the circumference of the butt and from 0.15 to 0.25 of an inch on the top.

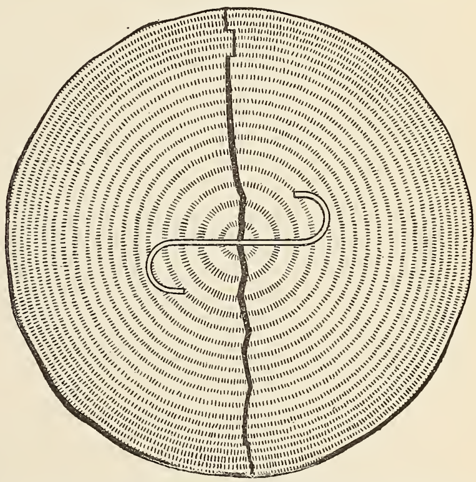

Fig. 2.—An S iron driven into butt of pole to prevent the opening of seasoning checks.

BRUSH METHOD OF TREATING POLES.

A very simple method of using a preservative consists in applying it to the surface of the wood with a brush. There are several patented or proprietary preservatives intended for use in this manner. While the experiments show good results from surface applications of antiseptic oils, this form of treatment does not present a complete solution of the question of pole preservation.

A brush method of treatment has the advantage of very low cost, owing to the small amount of preservative used and to the fact that no special treating apparatus is required. It is especially useful where the number of poles is small, or the region remote, so that the erection of even the most simple form of treating plant would not be justified. In the experiments, a penetration of from one-eighth to one-fourth inch was obtained in seasoned timber. Table 4 shows the amounts of preservative absorbed in a number of tests. The absorption was ascertained by weighing the vessel containing the preserva-

tive before and after each treatment, the difference in weight being taken as the amount absorbed by the pole. In all cases the preservative was applied hot.[a]

TABLE 4.—*Average absorption of creosote resulting from the brush method of treatment.*

Species.	Locality.	Absorption per pole.		Length of pole.	Length treated.	Number of poles averaged.
		1 coat.	2 coats.			
		Pounds.	*Pounds.*	*Feet.*	*Feet.*	
Chestnut	Parkton, Md	2.6	4.7	30	[a] 6	92
Southern white cedar	Wilmington, N. C		4.9	30	[a] 6	50
Northern white cedar	Escanaba, Mich	3.0	4.4	30	[a] 6	98
Western red cedar	Los Angeles and Wilmington, Cal.		6.5	40	[b] 8	75
Western yellow pine	Pollasky, Cal	2.4	3.6	40	[b] 7	32

[a] Between 2-foot and 8-foot points on butt. [b] From butt to height indicated.

Much care should be exercised to fill or coat all season checks with the preservative, for unless this is done the treatment is likely to prove ineffective, because decay will get a foothold in these checks. Only poles which are thoroughly seasoned should be treated and the preservative should not be applied when the surface of the wood is wet, as after a rain, or when very cold. In most cases, better results will be obtained by heating the preservative before applying. Bits of bark adhering to the poles should be carefully removed. While this is necessary in all treatments, it is especially important in brush treatments. Even if the treatment is apparently well done, decay may get a start in the untreated portion underneath the protecting layer of treated wood.

OPEN-TANK PROCESS OF TREATING POLES.

The open-tank process of timber treating, the principle of which has been described in another publication,[b] consists in subjecting the timber to successive baths of hot and cold preservatives. In this way atmospheric pressure is used to accomplish to a large extent what is more commonly accomplished by artificial pressure. The open-tank or nonpressure method, like the brush method already described, has the advantage that the preservative may be applied to the butt of the pole only, and this avoids the expense of applying it to the portion above ground, which in many cases is sufficiently durable without treatment. The efficiency of the method as regards the first object of treatment, the impregnation of the wood, is shown in Table 5. These figures represent typical results obtained in the treatments.

[a] As a rough approximation of the quantity of preservative required for pole treatments, 1 gallon may be allowed for each 25 square feet of surface to be covered, when two coats are applied.

[b] Forest Service Bulletin 78, "Wood Preservation in the United States," by W. F. Sherfesee.

TABLE 5.—*Average absorption and penetration of creosote obtained in the butt treatment of poles by the open-tank method.*

Species.	Absorption per pole.	Penetration.	Species.	Absorption per pole.	Penetration.
	Pounds.	*Inches.*		*Pounds.*	*Inches.*
Chestnut	21.5	0.3	Western yellow pine	81.4	3.1
Northern white cedar	48.4	.5	Lodgepole pine	34.0	1.0
Western red cedar	39.5	.8			

MANNER OF APPLICATION.

In the open-tank process the impregnation is accomplished by subjecting the timber to a change in temperature, by means of a hot followed by a cooler bath. Any one of three general methods may be followed to accomplish this result: (1) After the timber has been held in the hot preservative for the required length of time, the heating may cease and without other change the whole be allowed to cool; (2) the timber may be transferred from the hot liquid to another tank containing cooler preservative; (3) the preservative may be changed, the hot being drawn off and colder preservative run into the treating tank. The three methods of procedure indicate in a general way the different types of apparatus which may be used in the treatments.

DURATION OF TREATMENT.

Many of the experimental treatments were made with long treating periods in order to determine the maximum amount of penetration or absorption possible, and in some cases further tests showed that very much shorter periods of treatment gave as good or nearly as good results as the long treatments. While it is desirable, in commercial practice, to give the treatment in the shortest time possible, the fact should not be overlooked that the open-tank process of treatment is an impregnation process, and differs radically from a mere dipping process, or a coating of the surface with preservatives. It is therefore not advisable to reduce the length of the treatment to such an extent as to risk impairing its efficiency.

The time necessary to secure any desired penetration or absorption will vary with the species, the moisture condition of the timber, and many other factors, and must be determined by actual test in each case. Some species have a comparatively narrow sapwood, and a heartwood which it is difficult or impossible to penetrate; with such species it is useless to prolong the treatment after the sapwood has been penetrated. Other species, among which are loblolly and western yellow pines, have wide sapwood and treat very easily, and with these it is necessary to regulate the treating period so as to avoid an unnecessarily large absorption of the preservative.

Except in the case of very dry and porous woods, the absorption takes place mostly during the cooling process. The function of the hot bath is to prepare the wood for treatment. The drier the wood, the shorter the period of the hot bath needed. A long period in the cold bath, allowing the preservative to cool to atmospheric temperature, gives a saturated absorption. Shortening the cold bath and removing the timber while the preservative is still fairly hot gives a relatively deep penetration as compared with the quantity of preservative absorbed. This consideration is of especial value in treating porous wood.

TEMPERATURE OF HOT BATH.

In most of the experiments the hot bath was given at a temperature slightly above the boiling point of water, that is, from 215° to 230° F. There are a number of advantages in using a high temperature, and it is especially necessary if timber is not thoroughly air-dry. However, a number of successful treatments were made with temperatures of 200° and less. Further tests should be made to determine the lowest efficient hot-bath temperature for the treatment of seasoned poles. In order that volatilization of creosote may be reduced to a minimum, it is desirable that the hot bath be given at as low a temperature as possible without impairing the efficiency of the treatment.

INFLUENCE OF RATE OF GROWTH.

Among trees of the same species, those having wide annual rings commonly have wider sapwood than those whose growth has been less rapid, and since in many species it is only the sapwood that is penetrated, it follows that the pole of rapid growth will absorb more preservative than the one of slow growth. Chestnut poles showing a maximum growth of 2 rings to the inch absorbed the preservative to a depth of 0.75 of an inch, while others having 15 annual rings to the inch received a penetration of only 0.2 of an inch. The penetration in the case of northern white cedar poles averaged 0.6 of an inch for poles with less than 20 rings to the inch and 0.4 of an inch for those having more than 40 rings to the inch.

It is probable that the variation in wood structure due to difference in rate of growth, aside from the relative amounts of heartwood and sapwood, affects the absorption and penetration of preservative, but there is no conclusive evidence on this point.

INFLUENCE OF MOISTURE.

In general, the drier the wood the more readily it may be treated. Poles thoroughly air-seasoned require less time for treatment than those only partially seasoned. The treatment of green timber is

FIG. 1.—TREATING WHITE CEDAR BY BRUSH METHOD.

FIG. 2.—TREATING CHESTNUT POLES BY OPEN-TANK METHOD.

unsatisfactory because of the small absorption and irregular penetration of the preservative. Another important reason why unseasoned poles should not be treated is that such poles are likely to check in drying, and thus expose untreated wood to decay.

INFLUENCE OF SEASON OF CUTTING.

In the experiments with western yellow pine, poles cut in different seasons of the year differed greatly in the ease with which they absorbed the preservative, the summer-cut poles absorbing less than those cut at any other season. This difference in absorptive qualities may have been due to rate of seasoning and rate and conditions of growth, rather than to inherent differences in the wood due to the time of cutting. It is known that absorption may be retarded by "case hardening" that may result from too rapid drying. Tests on chestnut show that poles having the same moisture content, although they were cut at different periods of the year, absorb the same quantities of preservative.

INFLUENCE OF SOAKING IN WATER.

Chestnut poles which had been soaked in water two weeks and then seasoned did not absorb any more creosote than poles that had not been soaked. Soaking in water is rarely justified as a means of making wood more permeable to preservatives.

ADVANTAGES AND LIMITATIONS OF THE OPEN-TANK PROCESS.

The tests made by the Forest Service indicate that the sapwood of a great variety of species, including nearly all of our common native woods, when seasoned can be successfully impregnated by the open-tank process. The heartwood of many species offers considerable resistance to impregnation and can not be so well treated without pressure. However, with the exception of a few species having an unusually narrow sapwood, it is believed that the thorough treatment of the sapwood portion of round timber will afford good protection to the entire stick. Since poles are almost always used in the round, the open-tank process is especially well adapted to the treatment of this class of timber. The apparatus required is comparatively simple and inexpensive, especially where but few poles are to be handled, and if desired can be made portable.

The open-tank process is not adapted to the treatment of woods which are difficult to impregnate, nor to unseasoned or partially seasoned wood, and as regards economy of operation has not justified itself in plants designed for the treatment of the entire pole. The large amount of oil lost by volatilization from open tanks and the difficulty of accurately gaging and regulating the amount absorbed are other disadvantages.

RESULTS OF TREATMENTS, BY SPECIES.

CHESTNUT.

Chestnut is widely distributed throughout the entire Appalachian mountain region and is extensively cut for poles, ranking next to the cedars in the quantity used. The reported number of chestnut poles purchased in 1909 was 608,000.[a] Chestnut is durable, and the estimated average length of life of an untreated pole is from 10 to 12 years. The sapwood is very narrow, usually from about one-eighth to three-eighths of an inch wide. The heartwood of chestnut, like that of many other species, is difficult to impregnate with preservatives, and the penetration secured in the treatment is comparatively small. This fact, however, does not constitute a valid reason for not giving the wood such treatment as is possible. While the absorption of the small amount of preservative and the small penetration can not be expected to prolong the life of the timber to the same extent as would a greater absorption and depth of penetration, the increased life secured will undoubtedly more than pay for the cost of the treatment.

A large number of tests were made in the seasoning of chestnut poles, and the rate of seasoning was determined for a number of localities. Poles cut near Parkton, Md., and having an average green weight of 56 pounds per cubic foot, reached a weight of 47 pounds in from 4 to 8 months, depending upon the time of cutting. The fall and winter cut poles of the same lot, at the end of 12 and 9 months, respectively, had reached a weight of 45 pounds, and winter-cut poles at Thorndale, Pa., weighing 53 pounds per cubic foot to begin with, dropped to 42 pounds in 11 months, remaining practically stationary in weight at that point.

Brush Treatments.—Brush treatments were made in each of the tests with chestnut poles. As an example of the results obtained and because these poles will be referred to again in this bulletin,[b] the treatments made at Pisgah, N. C., are given in detail in Table 7. The poles were treated for a distance of 6 feet, beginning 2 feet from the butt.

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[a] Bureau of the Census: "Poles Purchased, 1909."

[b] Appendix, "Report on Inspection of Experimental Poles."

TABLE 7.—*Amount of preservative absorbed in the brush treatment of chestnut poles at Pisgah, N. C.*

Preservative sold as—	Number of coats.	Absorption per pole.		
		Average.	Maximum.	Minimum.
		Pounds.	*Pounds.*	*Pounds.*
Avenarius Carbolineum	2	4.1	5.1	2.9
Avenarius Carbolineum	1	3.7	4.6	2.4
S. P. F. Carbolineum	2	4.2	5.5	3.1
S. P. F. Carbolineum	1	3.2	3.9	2.5
Spirittine	3	6.7	9.0	4.9
Creosote	2	7.0	10.6	4.3
Creosote	3	6.5	8.3	3.8
Creosote	1	5.1	5.5	4.6
Imperial Wood Preservative	2	5.4	7.0	3.8
Creolin	2	6.4	8.4	4.5
Tar	1	7.0	....	....

The thin sapwood of chestnut has a tendency to scale off after the pole has been exposed for some time to the weather. An inspection of brush-treated chestnut poles shows that in certain cases the failure of the treatment was due to this cause. Possibly better results would be secured from brush treatments if the sapwood were shaved off for a few feet above and below the ground line, so that the preservative would be applied to the more firm heartwood.

TANK TREATMENTS.—Table 8 shows the results of the treatment of chestnut poles at Parkton, Md., with creosote, by the open-tank process. Treatments at Dover, N. J., and Thorndale, Pa., gave somewhat similar results.

TABLE 8.—*Absorption and penetration of creosote in the open-tank treatment of chestnut poles, Parkton, Md.*

Treatment.				Number of rings in outer inch.	Average penetration.	Average absorption.	Basis poles.
Hot oil.	Cooling oil.	Cold oil.	Temperature of hot oil.				
Hours.	*Hours.*	*Hours.*	*° F.*		*Inch.*	*Pounds.*	*Number.*
10	14	....	228	10	0.30	20.7	16
8	14	....	223	10	.29	21.3	8
6	14	....	225	8	.34	23.6	24
4	14	....	225	8	.33	20.9	24
6	....	2	229	9	.34	21.3	24
4	....	2	231	7	.38	20.6	16

It appears from this table that four hours in hot oil gives nearly as good a treatment as a longer period and that by changing the poles to the tank containing cold oil as good results are obtained in two hours as by leaving the poles in cooling oil overnight. The penetration in all cases was small, averaging from 0.3 to 0.4 of an inch. No tests were made with shorter periods of treatment, but it is probable that for practical purposes an efficient treatment can be given well-seasoned chestnut poles in a somewhat shorter period

than six hours. Poles with wide annual rings and wide sapwood absorbed more oil and showed a deeper penetration than those having a slower growth and narrower sapwood..

SOUTHERN WHITE CEDAR.

The white cedar of the South, or "juniper," as it commonly called by telephone men, is used locally to a considerable extent for poles. The woods known under the general name of "cedar" comprise a number of distinct species and differ in their durability, the white cedar of the southern swamps being somewhat less durable than the cedar of the Lake States.

Pole-using companies reported 44,000 [a] southern white cedar poles purchased in 1909. The average life is assumed to be from ten to thirteen years, but in unfavorable situations a large proportion of the poles fail in a shorter period. The sapwood, which is usually from one-half to 1 inch wide, decays very quickly. The poles used in the southern white cedar experiments were cut in the swamps of North Carolina and rafted about 90 miles down the Cape Fear River to Wilmington, where they were placed on skidways and seasoned until they reached a weight of from 25 to 26 pounds per cubic foot. Southern white cedar received brush treatments alone, and a number of different preservatives were used. As in the case of chestnut, a 6-foot space was treated, between the 2-foot and 8-foot points at the base of the pole. The results are summarized in Table 9.

TABLE 9.—*Amount of preservative absorbed in the brush treatment of southern white cedar* [a] *at Wilmington, N. C.*

Preservative sold as—	Number of coats.	Absorption per pole.		
		Average.	Maximum.	Minimum.
		Pounds.	*Pounds.*	*Pounds.*
Avenarius Carbolineum	2	3.6	4.7	2.6
S. P. F. Carbolineum	2	3.7	5.3	2.8
Do	1	1.6	1.6	1.6
Spirittine	3	4.7	5.5	4.1
Creosote	2	4.9	6.4	3.3
Do	3	7.1	8.0	5.6
Imperial Wood Preservative	2	4.4	5.3	3.4
Creolin	2	6.0	7.4	4.5
Tar	1	7.0		

[a] These poles were included in the experimental line set near Savannah, Ga., a report on the inspection of which is given in the Appendix.

NORTHERN WHITE CEDAR.

This species is very commonly used for poles throughout the central and eastern portion of the United States, and, together with smaller quantities of chestnut and oak, is the main source of supply

[a] Bureau of the Census: "Poles Purchased, 1909."

for these regions. Of the three and three-fourths million poles purchased in 1909 by telephone, telegraph, electric power, and steam railway companies, two and four-tenths millions, or about two-thirds, were cedar.[a] While the statistics do not separate the northern white cedar from other timbers known commercially as cedar, it is certain that by far the greater number are of this species, the principal source of supply of which is in the States bordering the Great Lakes. It makes a very desirable pole, since it lasts from twelve to fifteen years untreated. Northern white cedar is a high-priced pole timber, however, and it will undoubtedly pay to apply preservative treatment to increase the durability of the poles and thus decrease the annual service charge. The treating experiments included brush treatments with creosote and with carbolineum, and open-tank treatment with creosote. The poles were seasoned until approximately air-dry and weighed 22½ pounds per cubic foot at the time of treatment.

Brush Treatments.—The preservative was applied to the butts between the 2-foot and 8-foot points.

Table 10.—*Amount of preservative absorbed in the brush treatment of northern white cedar poles, Escanaba, Mich.*

Preservative sold as—	Number of poles averaged.	Absorption.		
		First coat.	Second coat.	Total.
		Pounds.	*Pounds.*	*Pounds.*
Carbolineum	98	2.4	1.5	3.9
Creosote	98	3.0	1.4	4.4

The penetration of the preservative in these treatments did not average more than one-sixteenth of an inch. The work was done during the winter, and, although the preservative was heated to between 200° and 220° F., the low temperature of the timber and atmosphere caused it to thicken on the surface of the wood. Under more favorable conditions the penetration should be deeper.

Tank Treatments.—Creosote tank treatments were made by heating the poles in the oil and maintaining the temperature at approximately 220° F. for from three to twelve hours and allowing them to cool in the oil overnight. A summary of the results is given in Table 11.

[a] Bureau of the Census: "Poles Purchased, 1909."

TABLE 11.—*Amount of preservative absorbed in the open-tank treatment of northern white cedar poles, Escanaba, Mich.*

Number of poles averaged.	Duration of treatment.		Absorption per pole.
	Hot oil.	Cooling oil.	
	Hours.	*Hours.*	*Pounds.*
34	3 to 5	Overnight	42
75	6	do	49
43	7 to 12	do	50

There was considerable irregularity in the results on different poles in the same treatment, but the general tendency is well shown by grouping the treatments and thus averaging a greater number of poles, as in Table 11. Little practical advantage seems to be gained by prolonging the hot bath above three or four hours, although the absorption averages somewhat higher. The average penetration obtained in the treatment was approximately 0.5 inch, varying from 0.2 to 1 inch. The sapwood of the poles varied from 0.5 to 1.0 inch in thickness.

A very large proportion of northern white cedar poles have unsound butts, 60 per cent of the experimental poles having defects more than 1 inch in diameter. In these tests, poles with sound butts absorbed, on an average, 11.1 pounds less than those with unsound butts.

The treatments on northern white cedar were made with one tank only, which prevented a change from hot to cold oil. Tests with other species indicate that by a change of baths the results obtained by cooling overnight could have been accomplished in a few hours.

WESTERN RED CEDAR.

The light and durable western red cedar is much used for poles on the Pacific coast and throughout the Northwest. Also, it competes to a certain extent with northern white cedar in the East, its form and size making it especially desirable for the larger classes of poles. The principal points of production are northern Idaho and western Washington. The relative durability of western red and northern white cedar under similar conditions is not known, and the testimony by pole users on this point is somewhat contradictory. Experiments with western red cedar poles from the Puget Sound region were made at Wilmington and Los Angeles, Cal.

BRUSH TREATMENTS.—Brush treatments of creosote and carbolineum were made, the preservative being applied to the butts of 40-foot poles to a height of 8 feet. The absorptions are shown in Table 12.

TABLE 12.—*Amount of preservative absorbed in the brush treatments of western red cedar (40-foot poles).*

CREOSOTE.

Number poles averaged.	Season cut.	Weight per cubic foot of poles. [a]	Absorption per pole.		
			First coat.	Second coat.	Total.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
12	Summer	22	([b])	([b])	12.4
22	Fall	23	([b])	([b])	8.7
21	Winter	24	2.3	1.5	3.8
20	Spring	28	2.0	1.5	3.5
	SOLD AS CARBOLINEUM.				
12	Summer	22	([b])	([b])	10.3
10	Fall	23	([b])	([b])	5.6
10	Winter	24	2.6	2.1	4.7
29	Spring	28	2.7	2.0	4.6

[a] Indicates stage of seasoning.
[b] First and second coats not recorded separately.

The absorption is relatively small when the preservative is applied to comparatively unseasoned poles that weigh as much as 28 pounds per cubic foot and forms scarcely more than a coating on the surface. The increase in absorption is very slight until the weight falls below 24 pounds, when it becomes rapid. At a weight of 22 pounds per cubic foot the absorption is two or three times as great as when the poles are in only a slightly greener stage. The penetration on the best seasoned poles averaged about one-eighth of an inch. Where the surface of the pole had become roughened by weathering, the penetration reached a maximum of one-half inch.

TANK TREATMENT WITH CREOSOTE.—In order to determine the maximum amount of creosote that could be injected, a number of treatments were made, keeping the poles in hot oil for periods ranging from one to six hours, at a temperature of between 220° and 230° F., and allowing them to cool overnight. For these treatments, summer and autumn cut poles were used, seasoned until they weighed, respectively, from 22 to 23½ and from 24 to 25 pounds per cubic foot. The absorption and penetration obtained are shown in Table 13.

TABLE 13.—*Absorption and penetration of creosote in the open-tank treatment of western red cedar poles at Wilmington, Cal.*

Duration of hot bath.	Summer cut.						Autumn-cut.		
	35-foot poles. [a]			40-foot poles. [a]			40-foot poles. [a]		
	Poles averaged.	Absorption.	Penetration.	Poles averaged.	Absorption.	Penetration.	Poles averaged.	Absorption.	Penetration.
Hours.	*Number.*	*Pounds.*	*Inches.*	*Number.*	*Pounds.*	*Inches.*	*Number.*	*Pounds.*	*Inches.*
1	24	36.5	0.68	....	....	....	....	....	....
2	....	....	....	23	45.5	0.90	12	33.0	0.60
3	33	34.0	.77	....	....	....	....	....	....
4	13	43.0	.90	12	46.0	.98	23	48.0	.65
5	....	....	....	24	46.5	1.00	24	43.0	.62
6	14	31.0	.80	....	....	....	....	....	....

[a] 35-foot poles were treated to a height of approximately 6.5 feet and 40-foot poles approximately 7 feet. The average volume of the butt of a 40-foot pole is 6.5 cubic feet.

These treatments represent complete or practically complete penetration of the sapwood. Little or no penetration was obtained in the heartwood. The shorter periods of heating (with the long cooling periods) give nearly as good results as longer periods of heating. The effect of duration of treatment is more fully brought out in Table 14.

TABLE 14.—*Effect of duration of treatment on the absorption and penetration of creosote in the treatment of western red cedar poles.* [a]

Duration of hot bath.	One hour cold bath.			Two hours cold bath.			Fifteen hours cooling.		
	Poles averaged.	Absorption per pole.	Penetration.	Poles averaged.	Absorption per pole.	Penetration.	Poles averaged.	Absorption per pole.	Penetration.
Hours.	*Number.*	*Pounds.*	*Inches.*	*Number.*	*Pounds.*	*Inches.*	*Number.*	*Pounds.*	*Inches.*
1	....	....	....	....	....	....	10	27.0	0.58
2	7	25.6	0.48	6	19.5	0.35	6	37.7	.65
3	5	18.5	.38	....	....	....	4	41.0	.60
4	6	26.0	.46	6	23.8	.61	5	32.5	.47

[a] Autumn-cut 40-foot poles seasoned to 23 pounds per cubic foot.

It is seen from Table 14 that good treatments may be given in three hours (two hours hot and one hour cold), but that the results do not average quite as high as in some of the longer treatments. The six-hour treatments (four hours in hot oil and two in cold) seem to give as good penetration as cooling overnight, and to accomplish this with the absorption of a smaller quantity of oil. Because of the irregularities in these results, the best period of treatment is not definitely determined, but it is believed that for very dry poles the short treatment will prove satisfactory, while if the timber is not so well seasoned it will be necessary to prolong the treatment. The effect of the degree of seasoning is illustrated in Table 15.

FIG. 1.—UNTREATED POLE OF SOUTHERN WHITE CEDAR (CHAMÆCYPARIS THYOIDES) AFTER FOUR YEARS' SERVICE.

FIG. 2.—CREOSOTED LOBLOLLY PINE POLE AFTER EIGHTEEN YEARS' SERVICE. NO SIGN OF DECAY.

FIG. 1.—CROSS-SECTION OF WESTERN RED CEDAR POLE BUTT, 10 INCHES IN DIAMETER, SHOWING PENETRATION OF CREOSOTE; OPEN-TANK TREATMENT.

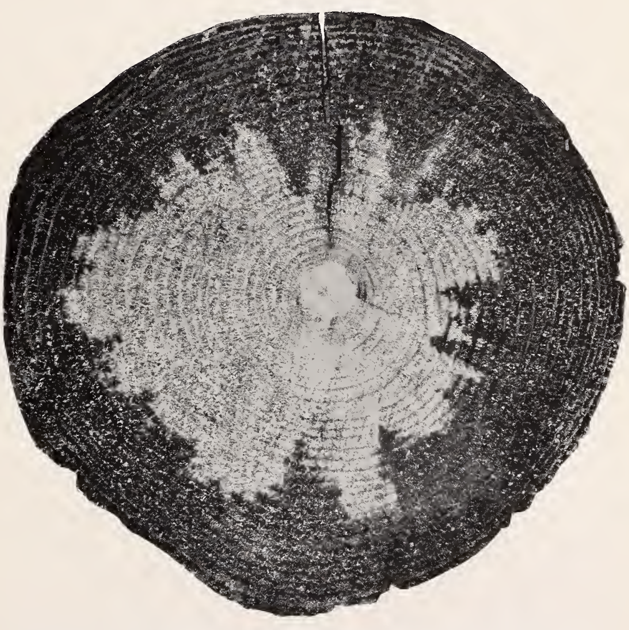

FIG. 2.—CROSS-SECTION OF WESTERN YELLOW PINE POLE BUTT, 14 INCHES IN DIAMETER, SHOWING PENETRATION OF CREOSOTE; OPEN-TANK TREATMENT.

TABLE 15.—*Effect of degree of seasoning on absorption and penetration of creosote in the treatment of western red cedar poles.*[a]

Time of cutting.	Weight per cubic foot before treating.	Absorption per pole.	Penetration.	Poles averaged.
	Pounds.	*Pounds.*	*Inches.*	*Number.*
Summer	22–23½	45.2	0.93	71
Fall	24–25	43.0	.63	59
Spring	28	28.4	.37	26

[a] Treatment consists of immersion from two to seven hours in hot oil and cooling overnight.

While the poles used in obtaining these averages did not all have the same period of treatment, the same range of treatments applies to each of the several groups. Other treatments were made, the results of which do not exactly coincide with those here given, but notwithstanding the great variability in individual poles the table serves to illustrate the relative absorptive power of the poles in different stages of seasoning.

TANK TREATMENT WITH ZINC CHLORID.—A number of treatments were made with zinc chlorid solution, mostly in long runs, keeping the bath at 212° F. for from four to seven hours and allowing the poles to cool in it overnight. The absorptions obtained are summarized in Table 16.

TABLE 16.—*Absorption of zinc chlorid solution in the treatment of western red cedar poles.*

Time of cutting.	Weight per cubic foot before treating.	Poles averaged.	Duration of treatment.		Average absorption per pole.
			Hot bath.	Cooling.	
	Pounds.	*Number.*	*Hours.*	*Hours.*	*Pounds.*
Summer	22½	8	5	Overnight	61.5
Winter	24	20	6	do	52
Spring	28	90	4–7	do	45

Table 16 illustrates the variation in amount of absorption of preservative solution obtained with poles in several stages of seasoning. A number of runs giving irregular results are not included in this table. Fall-cut poles seasoned to 23 pounds per cubic foot absorbed on an average only 30 pounds of solution per pole, and one lot of winter-cut poles seasoned to 25 pounds per cubic foot absorbed only 21 pounds per pole, the poles all being given treatment of practically the same duration. As a rule, however, the absorption of zinc chlorid solution was slightly higher than that of creosote for the same period of treatment and increases, other things being equal, as the moisture content of the wood decreases.

In a few treatments, the poles, instead of being left overnight in the cooling solution, were removed from the hot bath after from two to six hours and transferred to cold solution, in which they were left stand-

ing from one-half to two hours. This method resulted in an average absorption of 28 pounds solution per pole. In the treatment of western red cedar poles with zinc chlorid the aim should be to secure a complete saturation of the sapwood. The strength of the solution need not exceed 5 per cent.

Other Treatments.—A few tests were made with crude petroleum, but very little penetration was obtained. Poles seasoned until they weigh 25 pounds or less per cubic foot may be given a combination creosote and zinc chlorid treatment by heating them in a creosote bath and then changing and allowing them to cool in the zinc chlorid, but poles first treated with zinc chlorid solution will take very little creosote if dipped into the oil while they are in a saturated condition. However, such poles may be allowed to dry out and may then be dipped into a tank of heavy oil, or receive a brush treatment. A treatment of this character ought to prevent to a large extent the leaching out of the zinc chlorid.

WESTERN YELLOW PINE.

Western yellow pine is used for poles to a limited extent in certain parts of the Southwest, where the high cost of more durable pole timbers makes it necessary to find a cheaper substitute. The life of this timber, untreated, is very short. In the upper part of the San Joaquin Valley of California, where a study of this species was made, untreated pine poles last only two or three years; but since the wood when not exposed to the soil is fairly durable, it is believed that a butt treatment with a good wood preservative will result in a pole that will give good service. A butt-treated pine pole costs considerably less than an untreated cedar pole in this locality. Fortunately, western yellow pine is a timber which takes treatment very readily, and no difficulty is encountered in securing any desired absorption if the poles are seasoned.

Seasoning tests were made at Northfork, Madera County, Cal., where about 650 poles were cut, the cutting periods being distributed throughout the year. The green weight of the poles averaged slightly above 65 pounds per cubic foot, 40-foot poles averaging about 1,700 pounds. The treatments were made when the poles had lost from 50 to 55 per cent of their original weight, and weighed from 30 to 32 pounds per cubic foot. From three to ten months were required to reach this degree of dryness.

Brush Treatments.—Brush treatments were made with carbolineum and creosote, the preservative being applied to a height of 8 feet on the pole butts.

TABLE 17.—*Amount of preservative absorbed in the brush treatment of western yellow pine poles.*

Preservative sold as—	Poles averaged.	Absorption.		
		First coat.	Second coat.	Total
	Number.	*Pounds.*	*Pounds.*	*Pounds.*
Carbolineum	27	3.0	1.8	4.8
Creosote	32	2.4	1.2	3.6

The penetration for creosote ranged from one-sixteenth to one-fourth of an inch, averaging about one-eighth of an inch, and for carbolineum from one-sixteenth to one-half of an inch, with an average of about three-sixteenths of an inch.

TANK TREATMENTS WITH CREOSOTE.—Tank treatments were made both by allowing the poles to cool in the hot-bath tank, and by transferring them to a tank containing cooler oil. The results of a number of treatments by the former method are given in Table 18.

TABLE 18.—*Absorption and penetration of creosote in the open-tank treatment of western yellow pine poles.*

Poles averaged.	Duration of hot bath.	Maximum temperature.	Duration of cooling bath.	Final heating temperature.	Absorption per pole.[a]	Penetration.
Number.	*Hours.*	°*F.*	*Hours.*	°*F.*	*Pounds.*	*Inches.*
42	3	170–200	14	....	81.4	3.1
56	3	170–200	14	200	55.5	3.3

[a] The average volume of the portion treated was 6.25 cubic feet.

As shown in Table 18, three hours in hot oil and cooling overnight gave an average penetration of 3.1 inches, with an absorption of 81 pounds of creosote per pole, or 13 pounds per cubic foot. Reheating after the same period of treatment resulted in approximately the same penetration, with a final absorption, however, of only about 56 pounds per pole, or 9 pounds per cubic foot. A part of this difference may be accounted for by volatilization, which, while the wood and oil are hot, is doubtless rapid enough to have some effect during the interval between the removal of the pole from the tank and the weighing. Nevertheless, there is a substantial saving in creosote by removing the poles from the oil while hot (after cooling 10° or 20° from the maximum temperature), or by reheating the oil as in the case described. By this method the wood cells and cavities do not become supersaturated with oil to the same extent as when the treatment is completed with the creosote at a low temperature.

Very good results were also obtained by shorter treatment, both by allowing the poles to stand in the tank at the completion of the hot

bath until the temperature had fallen 20° or 30° F. or by transferring them to a tank containing cooler oil for a short period.

Absorption is much influenced by rainfall and atmospheric conditions. During hot, dry weather heating the poles for an hour in the hot oil and dipping them a few minutes in the cold tank resulted in an absorption of 6 pounds of creosote per cubic foot and a penetration of 2 or 3 inches. At this time some of the poles absorbed a large amount during the hot bath, without the cooling process. In the cooler, rainier period before the dry weather set in, the hot bath resulted in an absorption of only 6 or 8 pounds of oil per pole.

Tank Treatments with Zinc Chlorid.—Absorptions of zinc chlorid solutions average somewhat higher than creosote for the same periods of treatment. An average of about 18 pounds of solution per cubic foot[a] was obtained by giving the poles a hot bath of two or three hours, followed by cooling overnight. Standing the poles in cold solution for fifteen hours resulted in an absorption of nearly 10 pounds per cubic foot, and an absorption of 12 pounds to the cubic foot was obtained by a three-hour treatment, consisting of a hot bath followed by a change to cold solution. One-half a pound of dry zinc chlorid per cubic foot of timber is the amount commonly used in commercial practice for the treatment of crossties; that amount is approximated by using a 3 per cent solution for an absorption of 16 to 18 pounds or a 4 per cent solution if the absorption is 12 or 14 pounds to the cubic foot. Solutions varying in strength from 3 to 10 per cent were used in the tests in order that the effect of various quantities of zinc chlorid on the durability of the wood may be determined by the durability of the poles in service in an experimental line.

Tank Treatment with Creosote and Zinc Chlorid.—A treatment of both creosote and zinc chlorid may be given by using the former for the hot bath and the latter for the cold bath. The solution penetrates readily through the creosoted wood, the result being a pole with creosote in the exterior zone and zinc chlorid in the interior portion. It is, however, difficult to control the relative amounts of creosote and solution absorbed, and if the poles are quite dry more than the desired amount of the former may be taken up during the heating process.

Tank Treatments with Crude Petroleum.—Treatments with a heavy grade of crude petroleum were made, but impregnation is more difficult than with creosote. Two or three hours in hot oil, followed by cooling overnight, resulted in an average absorption of 56 pounds per pole and a penetration of 2 inches. There is little definite knowledge, however, of the value of crude petroleum as a wood preservative.

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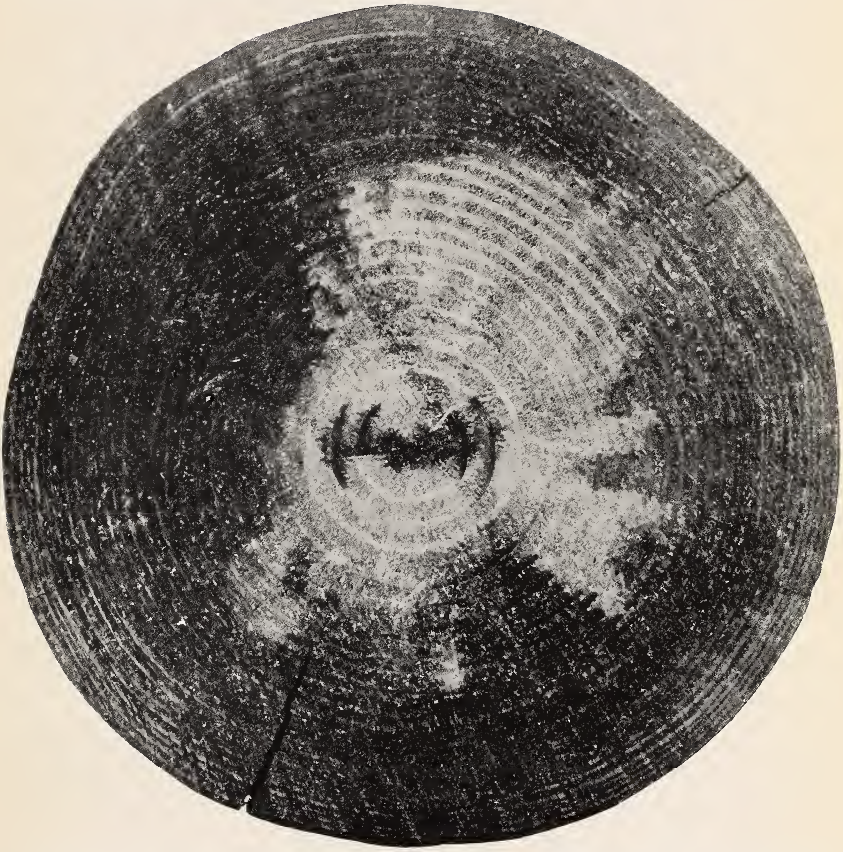
[a] The average volume of the portion treated was 6.25 cubic feet.



CROSS-SECTION OF A SMALL LOBLOLLY PINE POLE, SHOWING PENETRATION OF CREOSOTE.

LODGEPOLE PINE.

Lodgepole pine grows at high altitudes in the Rocky Mountains, and is extensively cut for lumber, ties, and mine timbers, and to a limited extent for poles. Like the yellow pine, it decays quickly in contact with the soil, but is durable when not so exposed. The tree grows tall and straight, with very little taper, and makes a well-shaped pole. In certain parts of the West, where there are large bodies of fire-killed lodgepole that remain standing for many years, sound and throughly seasoned, conditions for effective treatment are excellent. If given a butt treatment, this dead timber makes a durable pole, and in many localities the cost of the pine pole plus the cost of the treatment is less than that of the Idaho cedar untreated. The sapwood of lodgepole pine, which on pole-size timber may be an inch or an inch and a quarter thick, is easily impregnated. In the treatments made by the Forest Service four hours were required to accomplish this result, hot and cold baths of about equal duration being used. About 35 pounds of oil were absorbed in the butt treatment of 30-foot poles.

LOBLOLLY PINE.

The pines are much used for poles in the South, but, with the exception of the resinous heart of long-leaf pine, are not durable unless treated with preservatives. Loblolly pine because of its cheapness and ease of impregnation is very desirable if preservative treatment is contemplated. Moreover, its distribution, ease of reproduction, and rapidity of growth insure a steady and cheap supply.

When this timber is used it is necessary to treat the entire pole instead of only the butt, as in case of the species previously discussed, especially in the warmer and more humid localities of the South. The pressure method has ordinarily been used at commercial plants, but good results are obtained in the treatment of loblolly and other sap pines without pressure, or with very light pressure. A nonpressure plant, designed by the Forest Service for the treatment of poles, was recently erected at Winnfield, La. A penetration of 2 inches in seasoned poles may be obtained, with an absorption of from 8 to 12 pounds of creosote per cubic foot. These results were obtained by treatments consisting of an initial hot bath, a short cold bath, and a final heating. From four to five hours are required for the treatment, which permits two runs per day, working one shift only. Plate IV shows a cross section of a pole which had received a treatment of 10 pounds per cubic foot and showed an average penetration of 1¾ inches.

CYPRESS.

Cypress is usually considered a durable wood, and the heartwood is, in fact, one of the most durable of our native species. The sapwood, however, decays quickly, and this seriously weakens the pole. The width of the sapwood on pole-size trees is from three-fourths of an inch to $1\frac{1}{4}$ inches. While no tests have been made by the Forest Service, it is understood that the sapwood of cypress is easily impregnated. The treatment should extend high enough to prevent rank grass or bushes from coming in immediate contact with untreated wood, as decay, if it once gets a foothold in the sapwood, seems to have a tendency to extend upward on the pole. Cases have been called to the attention of the Forest Service where the sapwood of cypress poles deteriorated through the work of insects while the poles were piled awaiting shipment. If the bark is completely removed and the piles are open on skids over dry ground or raised out of reach of the water in swamps, this trouble may usually be avoided.

DESIGN AND OPERATION OF POLE-TREATING PLANTS.

EXPERIMENTAL PLANTS.

In the first experiments the tank was shallow with a sloping bottom, and the poles were placed in it at such an angle that the butts were submerged to a height of 7 or 8 feet. (See Pl. I, fig. 2.) The tank was substantially built of iron and was sunk nearly level with the surface of the ground, a fire box being first excavated underneath. No derrick is required for handling the poles when a tank of this character is used. A team is employed for skidding the poles alongside the tank, from where they may be rolled into position across the tank and the butt submerged by supporting the top at the required height. While this type of plant makes a cheap outfit for treating a small number of poles, it has many defects, among which are the large amount of oil required to fill the tank in proportion to its treating capacity and the large surface of oil exposed to evaporation.

The tank used in the experimental treatment of cedar poles at Wilmington, Cal., is shown in figure 3. This is an upright cylindrical tank 7 feet in diameter and 8 feet deep, constructed of one-fourth-inch iron.

A framework around the tank is used to support the poles in an upright position, and a false bottom, studded with short blunt spikes, prevents them from slipping. A derrick or ginpole operated by a power hoist is used for lifting them into and out of the tank. At the plant shown in the illustration an electric hoist furnished the power. The heating was at first done with a petroleum burner underneath the tank, but later a steam boiler was installed, and steam coils placed in

the tank. Twenty 40-foot poles could be placed in the tank at one time, but, as most of the treatments were made by heating and cooling in the same tank without change of oil, the capacity was limited to one run a day. This type of plant may be used for treating poles commercially where but comparatively few poles are to be treated. A storage tank with sufficient capacity to store at least one carload shipment of creosote should be added, and the capacity of the plant may be increased by the addition of a steam pump for changing the oil at the end of the hot bath, thus reducing the time required for the treatment. The entire cost of the plant with the improvements suggested would be about $1,000 or $1,200. A plant of this type, but of somewhat larger capacity, was subsequently built by the Forest Service at Norrie, Colo.

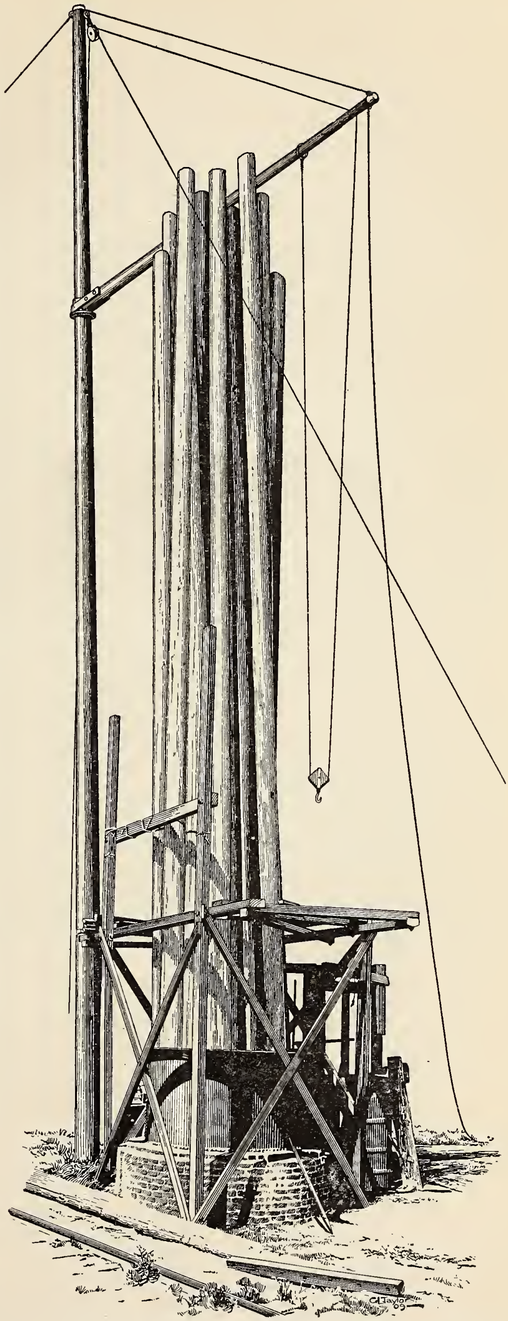


FIG. 3.—Open tank and ginpole used in experimental pole treatments.

COMMERCIAL PLANT FOR BUTT TREATMENTS.

A general plan of a proposed plant for the butt treatment of poles on a large scale is shown in figure 4. This plant combines the best features

of the experimental plants with additional labor-saving appliances necessary for the economical operation of a commercial plant. This plant is equipped with two treating tanks, each 7 by 9 feet and 9½ feet deep, and with an estimated capacity of thirty 8-inch 40-foot western yellow pine or red cedar poles. The daily capacity, figured on a basis of two charges for each tank, is 120 poles. Two storage and measuring tanks are provided, holding about 12,000 gallons of oil each. These tanks are designed with a relatively small diameter in proportion to their height, so as to allow more accurate gauging of the amount of oil used in the treatments. The plant is designed to be operated by changing the oil at the end of the hot bath, and in order that the change may be made quickly a receiving tank is provided. Hot oil from the treating tank is run into the receiving tank and the treating tank is then refilled from the cooler oil in the storage tanks. From the receiving tank the oil is returned to the storage tanks by means of a steam pump. The connections may be so made that one storage tank may be used exclusively for hot oil and the other for cold. Also, the oil may be transferred directly from one treating tank to the other. Such an arrangement will save fuel and will reduce the time required for treatment. A few coils of steam pipe should be placed in the storage and receiving tanks for keeping the oil in liquid condition, while in the treating tanks sufficient steam coil is required to heat the oil rapidly during the treatments. A boiler of about 50 horsepower capacity will be required for heating and power purposes. A plant of this type is suitable for erection at a central yard, where from 5,000 to 30,000 or more poles are handled yearly. The cost of the plant, erected, will vary between $4,000 and $5,000, depending on the locality.

Cost of Operation.—Following is a detailed statement of the estimated cost of pole treatment, based on a daily capacity of 120 poles and a total yearly output of 30,000 poles:

LABOR PER DAY.

1 yard foreman	$4.00	
1 plant engineer	4.00	
1 stationary engineer	4.00	
2 firemen, at $2.50	5.00	
5 laborers, at $2	10.00	
Total	27.00	
Labor charge per pole		$0.225

FUEL PER DAY.

2 tons coal, at $4	$8.00	
Fuel charge per pole		.067

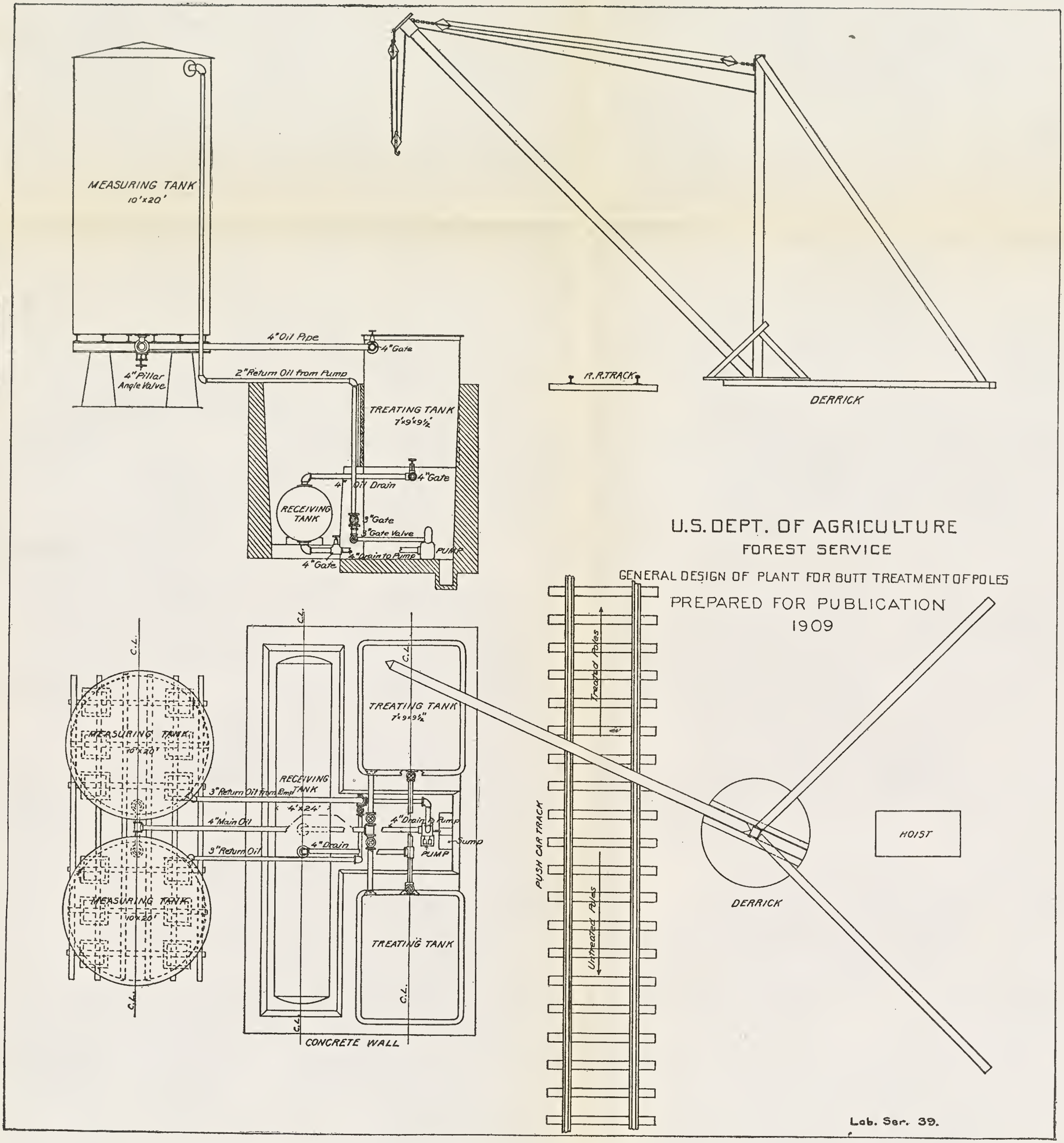


FIG. 4.—Plan of a commercial plant for the butt treatment of poles.

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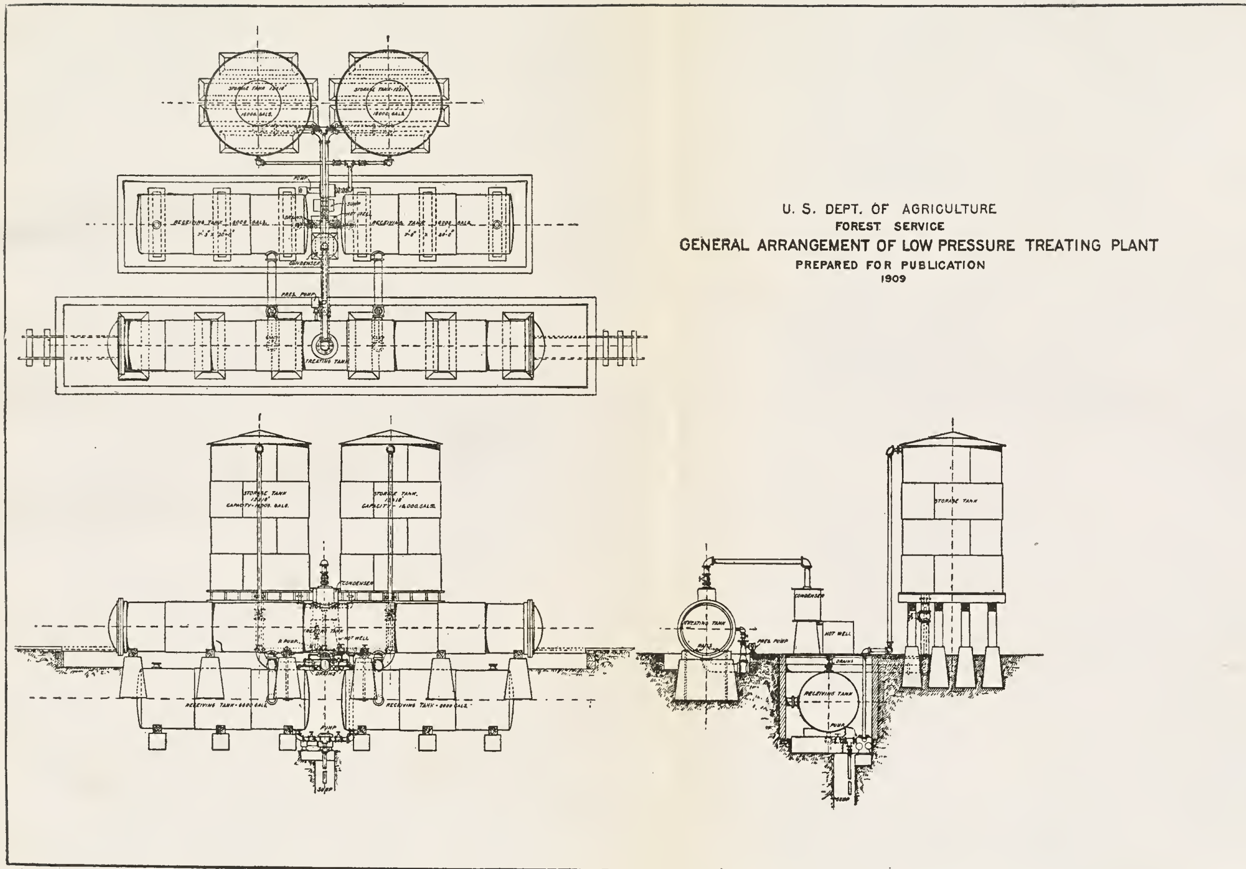

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FIG. 5.—Plan of a commercial plant where the entire pole is to be treated.

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MAINTENANCE PER YEAR.

Depreciation and repairs	$500.00	
Interest on investment in plant and preservatives	400.00	
Total	900.00	
Maintenance charge for pole		$0.030
Seasoning charge per pole (interest on investment)		.100
Total treating charge, exclusive of preservative		[a] .422

The total cost of treatment, exclusive of preservative, based on a liberal estimate for all charges, is thus seen to be $0.422 per pole. In the discussions of cost of treatments this charge is called $0.45.

DESIGN OF PLANT FOR TREATMENT OF THE ENTIRE POLE.

The principles of the nonpressure process are the same whether the entire pole or only the butt is treated, only the design of the plant being changed When the entire pole is to be treated, in place of the open upright tanks, a horizontal cylinder is used, into which trucks bearing the timber are admitted through doors opening on the ends, the doors being hermetically closed after the timber is admitted. This cylinder is similar in appearance to those used at pressure plants, but is constructed of lighter metal. The storage tank, receiving tank, and pump are arranged in a manner similar to those in the butt-treating plant.

It is recommended, however, that where a plant is erected for the treatment of the entire pole, it be of the low-pressure type in preference to the nonpressure. A treating cylinder capable of withstanding a maximum pressure of 70 pounds to the square inch may be constructed at a cost little in excess of a nonpressure cylinder, and the other apparatus is essentially the same, with the addition of a pressure pump. In operating the low-pressure plant, the preliminary hot bath is given as for a nonpressure treatment; at the completion of the hot bath, the retort may be refilled with cooler preservatives and pressure applied until the desired absorption has been obtained.

The general design of a low-pressure plant is shown in figure 5. The treating cylinder in this plant is 50 feet long and is capable of holding about eighty-five 25-foot poles. Two runs per day of ten hours were made, giving a daily capacity of 170 poles, which may be further increased by operating the plant twenty-four-hour days. The treating charge at a plant of this type, exclusive of preservative, will average about 2 cents per cubic foot of timber. A plant similar to the one shown in the figure costs about $10,000.

[a] In this estimate no charge is included for unloading and loading poles from and to railway cars, it being assumed that the plant is operated in connection with a storage or distributing yard.

COST OF POLE TREATMENTS.

The cost of the treating operations having been set forth, and the amount of preservative applied having been given, it remains now only to compute the cost of the preservatives and to add to this the cost of application in order to get the total cost.

Tank Treatment with Creosote.—The cost of creosote in carload lots (including transportation) may be placed at 10 cents per gallon for points east of the Mississippi River and in the vicinity of the Gulf ports west of the Mississippi. West of the Rocky Mountains the cost may be placed at 20 cents per gallon. The cost of applying the treatment will vary greatly in different regions, owing to the difference in wage scales, but for convenience the general average already estimated will be used in all cases.

Table 19.—*Examples of cost per pole of open-tank treatments with creosote (estimated).*

BUTT TREATMENT ONLY.

Species.	Size of pole.		Amount of creosote applied.		Cost of treatment..		
	Diameter.	Length.	Per cubic foot.	Per pole.	Preservative.[a]	Operations.	Total.
	Inches.	*Feet.*	*Pounds.*	*Pounds.*	*Dollars.*	*Dollar.*	*Dollars.*
Chestnut	7	30	....	25	0.30	0.45	0.75
Northern white cedar	7	30	....	50	.60	.45	1.05
Western yellow pine	8	40	6	37.5	.90	.45	1.35
Do	8	40	10	62.5	1.45	.45	1.90
Western red cedar	8	40	6	39	.90	.45	1.35
Lodgepole pine	7	35	....	35	.80	.45	1.25
ENTIRE POLE TREATMENT.							
Loblolly pine	5	25	10	80	.95	.15	1.10
Do	6	35	10	180	2.10	.35	2.45

[a] A gallon of creosote is estimated to be 8½ pounds.

The sizes of poles mentioned in this estimate are those mostly used in the experimental treatments. On account of the greater taper of chestnut and northern white cedar the 30-foot poles of these species take up about the same lateral space in the treating tank as 40-foot poles of the western cedar and yellow pine. Lodgepole pine tapers but little, and while greater tank capacity would be secured in the treatment of 35-foot poles of this species than for the other species and sizes named, the gain in this respect is more than offset by the high wage rate prevailing throughout the Rocky Mountain region.

Tank Treatment with Zinc Chlorid.—The use of zinc chlorid as a preservative has been discussed in connection with the treatment of western red cedar and yellow pine poles. Supposing that the customary half pound of salt to the cubic foot of timber is applied and that the cost of operations is the same as for creosote treatment,

the cost for the butt treatment of 40-foot poles of either of these species would be approximately 65 cents.

TANK TREATMENT WITH CRUDE PETROLEUM.—Crude petroleum was used in the treatment of western yellow pine poles. With an application of 9 pounds of oil to the cubic foot (about 8 gallons per pole) and estimating the cost of the treating operations as before, the total cost of a butt treatment with this preservative is about 85 cents.

BRUSH TREATMENT.—The labor cost of applying a brush treatment is about 5 cents for each coat if the poles are treated on the skidways. From one-half to 1 gallon of creosote per pole will be required, depending on the timber and the thoroughness of the treatment. The total cost of a brush treatment with creosote, applying two coats, is therefore from 15 to 20 cents in the East and from 20 to 30 cents in the West. However, if the creosote be purchased in small quantities, as will usually be the case for brush treatments, the price will be higher than that used in these estimates.

INCREASED LIFE AFFORDED BY PRESERVATIVE TREATMENT.

Before deciding on the use of a preservative treatment, the pole user naturally wishes to know what length of life may be expected from the treated timber. In any discussion of this question it is well to keep clearly in mind what character of treatment is meant. Brush coatings of preservatives usually amply repay their cost if an increase of one to two years is added to the natural life of the untreated timber, but a great degree of permanency in the protection afforded should not be expected from application of so small a quantity of preservative. However, results already obtained in these tests indicate that an averaged increased life of at least three years may be expected from brush applications of good wood preservatives.

If, instead of a light surface application, the butt of a pole be more deeply impregnated with the preservative, the pole will probably be limited by the life of the top rather than by the life of the butt. There are practically no data on the ultimate life of the upper portion of the pole, since replacements are commonly made because of failure of the butt. The fact that almost all pole failures are due to butt decay is a convincing argument for the efficiency of this form of treatment. A life of twenty years for butt-treated chestnut and western cedar and of twenty-two years for northern white cedar poles is believed to be a conservative estimate, and in the drier western climate it is believed that butt-treated pine poles may be depended on to give twenty years' service.

While the information relative to the life of poles which have been treated entire is more extensive than with regard to those which have received butt treatment, this also is meager. The develop-

ment of the creosoting industry in this country is quite recent; however, authentic instances are on record of creosoted pine poles which have been in service twenty years and longer and are still apparently as good as when first set. Records of the German Postal and Telegraph Department [a] covering fifty-two years show an average life of 20.6 years for creosoted pine poles.

FINANCIAL SAVING.

Closely related to the increased life afforded by preservative treatment is the matter of the saving in money. The treatment adds to the cost of the pole, but also increases the length of its service. The question reduced to its simplest form is, Does the increased life repay the cost of treatment? The comparison may best be made on the basis of annual cost; that is, the initial cost of the pole divided by the number of years' service it is expected to render, allowing a reasonable rate of interest in the computation. The computations in Table 20 are made on a basis of 5 per cent interest.

TABLE 20.—*Estimated financial saving due to creosote treatment of poles.*

Species.	Size of pole.		Character of treatment.	Amount of preservative applied per pole.	Estimated cost of treatment.	Estimated cost of pole in place.	Estimated length of life.	Annual cost.	Annual saving due to treatment.
	Diameter.	Length.							
	In.	*Feet.*		*Lbs.*	*Dolls.*	*Dolls.*	*Yrs.*	*Dolls.*	*Dolls.*
Chestnut	7	30	Untreated			6.00	10	0.77	
			Brush treatment	7	0.20	6.20	13	.66	0.11
			Open-tank treatment	25	.75	6.75	16	.62	.15
Southern white cedar	7	30	Untreated			5.00	10	.65	
			Brush treatment	5	.20	5.20	13	.55	.10
			Open-tank treatment	40	.95	5.95	18	.51	.14
Northern white cedar	7	30	Untreated			7.00	14	.71	
			Brush treatment	5	.20	7.20	17	.64	.07
			Open-tank treatment	50	1.05	8.05	22	.61	.10
Western red cedar	8	40	Untreated			9.50	10	1.23	
			Brush treatment	8	.30	9.80	13	1.04	.19
			Open-tank treatment	40	1.35	10.85	20	.87	.36
Western yellow pine	8	40	Untreated			8.00	3	2.94	
			Brush treatment	6	.30	8.30	5	1.92	1.02
			Open-tank treatment	60	1.90	9.90	20	.79	2.15
Lodgepole pine	7	35	Untreated			7.00	5	1.62	
			Open-tank treatment	40	1.25	8.25	20	.66	.96
Loblolly pine	6	35	Untreated			2.50	3	.92	
			Entire pole, open tank or pressure.	200	2.45	4.95	20	.40	.52

The financial saving is seen to be greater when treatment is applied to poles having little natural durability than when applied to long-lived timbers. This is due to two main reasons: (1) The annual cost of nondurable poles used untreated is relatively very high because

[a] Archiv für Post und Telegraphie, Nr. 16, Berlin, August, 1905.

of the frequent replacements required, and (2) the cost of the treatment is relatively less (when interest on the investment is included), since a shorter time must elapse before the benefits begin to be realized. It is also obvious that, where the initial cost of the timber and of the setting are high, prolonging the life of poles results in greater financial benefit than when these costs are more moderate.

In Table 20 the annual cost of treated and untreated poles is compared, assuming as a basis of the computations representative values in typical localities for each species. For example, the cost of a western red cedar pole is taken at southern California coast cities, of lodgepole pine in the Rocky Mountain region, and of loblolly pine in the South. Sometimes it is of greater interest to compare the cost of different species in the same locality, and especially to compare an untreated pole of a durable species with a treated pole of an "inferior" species.

A 7-inch 35-foot lodgepole pine pole is worth $3 f. o. b. cars in the mountain region of Colorado. Recently an Idaho cedar pole of the same size could be obtained in the same region for $5.25, including transportation. A butt treatment for the pine pole will cost $1.25, making the total cost of the treated pole $4.25. Let it be assumed, however, that owing to local freights the first cost of the untreated cedar and the treated pine at the point of use will be the same, namely, $5.25. Setting, which is very costly in a mountainous region, may be figured at $4, making the cost of either pole in place $9.25. Assuming that the untreated cedar will last in this region fifteen years, and the treated pine twenty years, the annual costs of the two poles become $0.89 and $0.74, respectively, or an annual saving of $0.15 in favor of the pine pole. At the rate of forty poles to the mile this will amount to a saving of $6 each year for each mile of line in operation.

In the vicinity of Fresno, Cal., a 40-foot cedar pole brought from Washington costs $8, while a native pine pole may be obtained for $5. A heavy butt treatment of creosote may be given the latter for $1.90, making the total cost $6.90. Allowing $3 for setting in either case, the respective costs of the poles in line are $11 and $9.90. Pole users in this locality estimate the life of cedar at ten years, while it is believed that the treated pine will last twenty years. On this basis the respective annual costs of the two poles are $1.42 and $0.79, an annual saving of $0.63 on every native treated pole in use. In this case there is a saving even in the first cost, and a relatively greater saving when the lives of the two poles are compared.

RELATION OF PRESERVATIVE TREATMENTS TO POLE SPECIFICATIONS.

It is the practice in pole specifications to require poles of larger diameter than the actual service requires, in order that a certain amount of deterioration by decay shall be allowable before replacement is needed. For example, if it is computed that a circumference of not less than 28 inches of sound wood in the pole at the ground line is required to support the strain to which the line is liable to be subjected, and the poles used have a circumference of 36 inches at the ground line, then 8 inches deterioration, or the equivalent of a depth of decay of approximately $1\frac{1}{4}$ inches, is allowable before replacement is required.

In some species otherwise durable the sapwood decays very quickly. Untreated white cedar poles in Georgia, inspected after being set in line four years, showed from 45 to 50 per cent of the number with sapwood completely decayed at the ground line, which amounted to an average deterioration of 4 inches in the circumference, equivalent to an average depth of decay of fully five-eighths of an inch. Cypress poles in Florida, inspected after being in the ground seven years, showed an average depth of decay of 0.8 inch at the ground line. The heartwood of these poles is sound, and in nearly all cases is of sufficient dimension to meet the requirements of the line in which they are used, although, graded by the butt circumference, they fall decidedly lower than their original class. If there had been used originally poles of the grade represented by these after the sapwood has decayed, and if the butts had been well treated with creosote, so that their full size and strength would be maintained, not only would the poles be equally strong with those now in use, but their ultimate length of life would be greater, and the difference in cost between the two grades of poles would in some cases offset the cost of the treatment. Pole users are, therefore, paying money that might more profitably be spent for preservative treatment for poles of large diameter in order to secure longer life in that way. In short, the possibility of using lighter poles and giving them preservative treatment, so as to maintain their full size and strength, merits the attention of all pole users.

GROWTH AND FORM OF POLES.

Table 21 gives the average time required for poles of various species and sizes to grow; also the natural taper of such poles, as shown by circumference measurements at the ground line of the pole when set (6 feet from the butt of the pole) and at the top. The table is compiled in part from measurements made on poles used in the seasoning and treating tests and in part from other commercial tree studies of the Forest Service.

Table 21.—*Form and rate of growth of pole timber.*

Species.	Location.	Nominal sizes of poles.		Age.	Circumference at ground line of pole.[a]	Circumference at top.	Amount of taper on circumference.	
		Diameter.	Length.				Ground line to top.[a]	Average each 10 feet.
Chestnut:		*Inches.*	*Feet.*	*Years.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Grown from seed.	Maryland	7	30	56	37.3	27.8	9.5	4.0
Grown from sprout	do	7	30	51	37.6	28.4	9.2	3.8
Northern white cedar.	Northern Michigan	7	30	190	36.4	23.9	12.5	5.2
Western yellow pine	Madera County, Cal	8	40	65	38.6	25.1	13.5	4.0
Lodgepole pine	Montana	7	35	90	30.8	22.0	8.8	3.0
Loblolly pine	Texas	7	35	30	28.9	22.0	6.9	2.4
Western red cedar	Western Washington	8	40	82	38.9	27.0	11.9	3.5

[a] 6 feet from butt.

A striking contrast appears in this table between the rate of growth of northern white cedar and loblolly pine. The cedar, under natural forest conditions, is a very slow-growing tree and will become increasingly scarce as a source of pole supply, as present stands become more and more exhausted. On the other hand, loblolly pine is a good example of a number of more rapid-growing species which, possessing all essential qualities for poles except durability—a defect which may be overcome by preservative treatment—will, through their rapidity of growth and ease of reproduction, continue to be available in sufficient quantities and at moderate prices, thus assuring pole users of supplies for future needs.

SUMMARY.

The more important conclusions from the investigations discussed in this bulletin are:

Seasoning of poles reduces their weight, commonly from 16 to 30 per cent, and even more for some species, with a corresponding decrease in the cost of transportation. Thorough seasoning is essential if the poles are to be treated with preservatives.

In general, poles cut during the spring and summer lose weight most rapidly. Poles cut during autumn and winter lose weight less rapidly, but more regularly. Too rapid seasoning may be detrimental to the timber by causing excessive checking.

Shrinkage of poles during seasoning is very slight, and does not exceed 1 per cent on the circumference.

A simple and inexpensive way of using a preservative consists in applying it to the surface of the pole with a brush. Butt treatments made in this manner with a good preservative may be expected to add two to three years to the life of the poles and more than repay their cost, but are not as effective as impregnating the wood with the preservative.

Impregnation of many pole timbers, especially the sapwood of round timbers, may be successfully accomplished in open tanks, without the use of artificial pressure, by immersions in hot and cold preservative, the cold following the hot.

The open-tank process for the treatment of poles has the advantage that it is possible to apply the preservative to the butts only, with a great saving in the amount used. Plants for butt treatments may be constructed in a simple and inexpensive manner.

Preservative treatment is profitable financially, the increased durability of the timber decreasing the annual service charge. Relatively greater benefits are derived from the treatment of nondurable woods than from the treatment of those which possess great natural durability.

Preservative treatment makes possible the use of poles of smaller butt circumference, since allowances usually made for deterioration by decay need not be considered, when it is certain that the full size and strength of the poles will be retained through a long period of years.

By the application of preservative treatment, many species of timber not naturally durable and formerly not considered suitable for poles may be used for this purpose, thus opening up new sources of supply, and greatly relieving the pole situation from the threatened exhaustion of those woods now most commonly used.

APPENDIX.

REPORT ON INSPECTION OF EXPERIMENTAL POLES.

In the summer of 1905 a number of treated and untreated poles were set in the Augusta-Savannah and Helena-Meldrin[a] lines of the Southern Bell Telephone and Telegraph Company, near Savannah, Ga. The experiment dealt with 816 poles, one half southern white cedar and the other half chestnut, the treated poles being alternated with the untreated ones, and the series arranged as shown in the following plan:[b]

TABLE 22.—*Setting plan of poles in experimental line established in cooperation with the Southern Bell Telephone and Telegraph Company near Savannah, Ga.*

Pole No.	Preservative[a] sold as—	Condition.	Pole No.	Preservative[a] sold as—	Condition.
1	Avenarius Carbolineum	Seasoned.	18	No treatment	Seasoned.
2	No treatment	Do.	19	Creosote	Do.
3	Avenarius Carbolineum	Do.	20	No treatment	Green.
4	No treatment	Green.	21	Imperial Wood Preservative	Seasoned.
5	S. P. F. Carbolineum	Seasoned.	22	No treatment	Do.
6	No treatment	Do.	23	Imperial Wood Preservative	Do.
7	S. P. F. Carbolineum	Do.	24	No treatment	Do.
8	No treatment	Green.	25	Creolin	Do.
9	Spirittine	Seasoned.	26	No treatment	Do.
10	No treatment	Do.	27	Creolin	Do.
11	Spirittine	Do.	28	No treatment	Green.
12	No treatment	Green.	29	Tar	Seasoned.
13	Creosote	Seasoned.	30	No treatment	Do.
14	No treatment	Do.	31	Tar	Do.
15	Creosote	Do.	32	No treatment	Green.
16	No treatment	Green.	33	Tar	Do.
17	Creosote	Seasoned.	34	No treatment	Seasoned.

[a] See page 46 for analysis of preservatives.

The series is repeated twelve times for each species, series No. 2 beginning with pole No. 35, series No. 3 with pole No. 69, etc.

The inspection of the line was made in April and May, 1909, by representatives of the American Telegraph and Telephone Company and of the Forest Service. A careful examination was made of each pole and its condition noted. In Tables 23 and 24 and in figure 6 the relative efficiencies of the various treatments are compared by grouping the poles with reference to the amount of decay in the sapwood at or near the ground line. The number and percentage of poles having decay in the heartwood is also shown in the tables.

[a] In Forest Service Circular No. 104 the line is referred to as the "Savannah-Abbeville-Eastman" line.

[b] See "Southern white cedar," page 20, and "chestnut," page 18, for record of treatments.

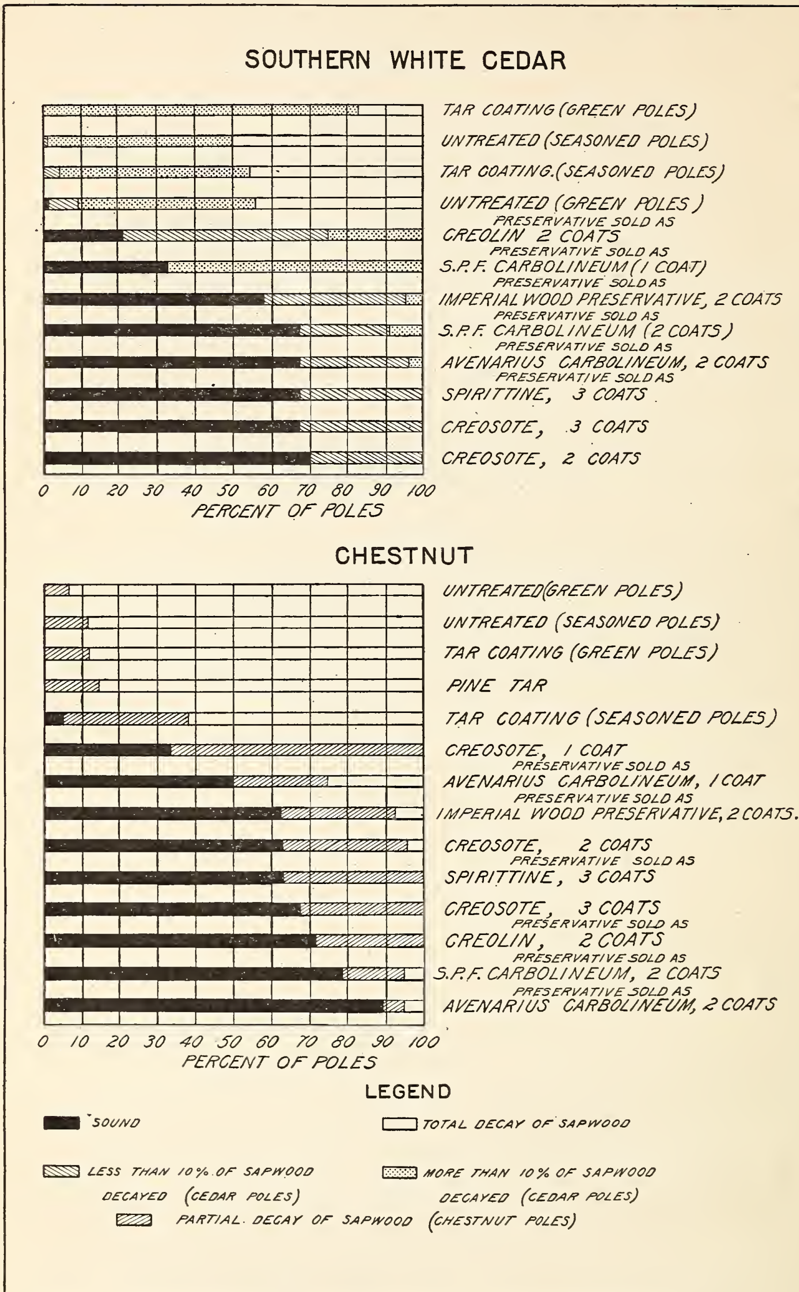

FIG. 6.—Diagram showing condition of experimental poles.

It should not be inferred, however, that because a pole is classed in the latter group decay is necessarily of a serious character, as in most cases the amount of heartwood decayed is small. The class indicates only that decay has extended beyond the sapwood portion into the heartwood without regard to the amount of decay. A very few of the poles were decayed to such an extent that replacement was required. The number of such is also noted.

Table 23.—*Summary of condition of southern white cedar poles in experimental line established in cooperation with the Southern Bell Telephone and Telegraph Company near Savannah, Ga.*

Treatment.	Total number.	Sound poles.		10 per cent or less of sapwood decayed.		More than 10 per cent; less than total decay of sapwood.		Total decay of sapwood.		Decay in heartwood.		Replacement needed.	
		No.	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
Untreated seasoned poles	104			1	1	51	49	52	50	6	6	1	1
Untreated green poles	96	1	1	7	7	45	47	43	45	2	2		
Preservative sold as Avenarius Carbolineum (2 coats)	24	16	67	7	29	1	4			1	4		
Preservative sold as S. P. F. Carbolineum (2 coats)	21	14	67	5	24	2	9						
Preservative sold as S. P. F. Carbolineum (1 coat)	3	1	33			2	67						
Creosote (2 coats)	33	23	70	10	30								
Creosote (3 coats)	15	10	67	5	33								
Preservative sold as Spirittine (3 coats)	24	16	67	8	33								
Preservative sold as Imperial Wood Preservative (2 coats)	24	14	58	9	38	1	4						
Preservative sold as Creolin (2 coats)	24	5	21	13	54	6	25						
Coal tar (green poles)	12					10	83	2	17				
Coal tar (seasoned poles)	24			1	4	12	50	11	46				

Table 24.—*Summary of condition of chestnut poles in experimental line established in cooperation with the Southern Bell Telephone and Telegraph Company near Savannah, Ga.*

Treatment.	Total number.	Sound poles.		Partial decay of sapwood.		Total decay of sapwood.		Decay in heartwood.		Replacement needed.	
		No.	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
Untreated seasoned poles	114			12	11	102	89	70	61	1	1
Untreated green poles	95			7	7	88	93	35	37	2	2
Preservative sold as Avenarius Carbolineum (2 coats)	18	16	89	1	6	1	6				
Preservative sold as Avenarius Carbolineum (1 coat)	4	2	50	1	25	1	25				
Preservative sold as S. P. F. Carbolineum (2 coats)	18	14	78	3	17	1	6				
Preservative sold as S. P. F. Carbolineum (1 coat)	2	2	100								
Creosote (1 coat)	3	1	33	2	67						
Creosote (2 coats)	39	24	62	13	33	2	5	3	8		
Creosote (3 coats)	6	4	67			2	33	1	17		
Preservative sold as Spirittine (3 coats)	24	15	63	9	38						
Preservative sold as Imperial Wood Preservative (2 coats)	24	15	63	7	29	2	8				
Preservative sold as Creolin (2 coats)	24	17	71	7	29			1	4		
Coal tar (green poles)	8			1	12	7	88	3	38		
Coal tar (seasoned poles)	21	1	5	7	33	13	62	6	29		
Pine tar	7			1	14	6	86				

DISCUSSION OF RESULTS.

SOUTHERN WHITE CEDAR POLES.

With the exception of the tar and creolin treatments and a few treatments with only one coat of carbolineum or creosote, from 58 to 70 per cent of the treated cedar poles are in a perfect state of preservation. On the other hand, the sapwood of the untreated poles is in nearly every case completely or almost completely decayed, and in a few cases the decay extends to the heartwood. While all the poles having more than 10 per cent decay, yet less than total decay of the sapwood, are put into one group, the proportion of the untreated poles in this group that falls near the upper limits in amount of decay found is much greater than that of the treated poles.

When decay occurred in the treated poles (referring only to those treatments which show a high percentage of sound poles) it was found most often in sapwood which was not penetrated by the preservative, the outer wood to a depth of perhaps a quarter of an inch, or as deep as the preservative had penetrated, being in a sound condition. Moreover, such decay was usually small in amount and occurred in strips frequently only a few inches wide, extending lengthwise of the pole. White ants, or termites, were very commonly found in the poles; like decay, their destruction was confined largely to the untreated poles and to wood which the preservative had not reached beneath the protecting bands of the treated poles. These insects excavate galleries in the wood, and it is believed that to a considerable extent they hasten decay.[a] However, as the borings of the termites were in nearly all cases accompanied by decay, it was usually impossible to determine which agency was primarily responsible for the destruction, and in the tables no distinction is made between these two causes of deterioration.

The amount of deterioration was determined by measuring the circumference just above the decayed portion and the circumference of the sound wood at the point of greatest decay, first scraping away the disintegrated wood. The difference between these two measurements gives the approximate amount of deterioration, which for 100 poles, having all the sapwood decayed, was on an average 4.03 inches. This corresponds to an average depth of decay of approximately five-eighths of an inch for these poles. Other poles similarly decayed, but on which good measurements could not be obtained, are not counted in this average.

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[a] It is stated by the Bureau of Entomology that white ants, while usually confining their work to the outer layers of wood where there is incipient decay, will often completely honeycomb the sound wood of poles.

CHESTNUT POLES.

The same general conditions apply to the chestnut poles, but decay is less in amount, although the number of poles having decay of heartwood is very much greater. The sapwood of chestnut is narrow and its decay does not appreciably affect the strength of the pole. Decay does not, however, halt when it reaches the heartwood, but continues steadily, although probably at a decreased rate. The average depth of decay on 222 chestnut poles having at least all of the sapwood decayed was found to be 0.25 of an inch.

IRREGULARITIES IN RESULTS.

Several irregularities appear in the results of the tests as shown by the tables; these, however, may be regarded as largely accidental and do not destroy the value of the whole. For example, two chestnut poles were treated with only one coat of the preservative sold as carbolineum. Both are sound, and therefore the percentage of sound poles under this head is 100. Eighteen poles were given two coats of the same preservative; of these 14, or 78 per cent, are sound. It is not a necessary conclusion that one coat of this preservative is more efficient than two coats, although it might be concluded that one coat affords an effective treatment. Even the latter conclusion is not entirely warranted after a comparison with the results obtained from one and two coats of other preservatives and from one coat of the same preservative on cedar poles. A somewhat similar case is shown in the creosote treatments on cedar poles. Thirty-three were treated with two coats of creosote and 15 with three coats. Seventy per cent of those treated with two coats are sound and only 67 per cent of those receiving three coats. The conclusion is not that two coats are more efficient than three, but in the absence of other data we may infer that a third coat does not add to the efficiency of the treatment.

HEIGHT OF DECAY ABOVE GROUND LINE.

The height above ground line to which decay extended was noted on 301 cedar poles. On most the decay did not extend upward more than one-half foot, and in relatively few cases did it extend more than 2 feet above ground, the height depending to a large extent on the character of the vegetation in the immediate vicinity of the pole.

TABLE 25.—*Height of decay above ground line—Cedar poles.*

Height of decay above ground.	Number of poles.	Per cent.
One-half foot or less	205	68
More than one-half foot	96	32
More than 1 foot	46	15
More than 2 feet	18	6
More than 3 feet	5	2

The sapwood of chestnut poles has a tendency to flake off, and the surface of the poles is frequently scaly. Aside from this scaling off of the sapwood, decay did not extend any appreciable distance above the ground.

It appears from Table 25 that if cedar poles be treated to a height of 2 to 3 feet above the ground, ample protection from decay will be afforded. Treatment need not extend any higher on chestnut poles, and possibly may be somewhat lower with safety.

DETERIORATION SHOWN BY CHANGE OF GRADES.

A grading of the untreated cedar poles was made, based on the butt circumference given in the specifications of the American Telephone and Telegraph Company and upon the measurements, already described, of the poles after use. The number of poles in each class graded by circumference above the decayed portion and the grading of the same poles based on the circumference of sound wood at the point of greatest decay is shown in Table 26:

Table 26.—*Grading of poles based on original butt circumference and circumference of sound wood at time of inspection.*

Classes.	Number of poles, graded by original circumference.	Number of poles, graded by circumference of sound wood at time of inspection, by classes.					
		A.	B.	C.	D.	E.	Below E.
A	56	16	31	9			
B	70		27	32	9	1	1
C	35			9	10	6	10
D	18				5	4	9
Total	179	16	58	50	24	11	20

Of the 179 poles included in the above classification, only 57 have not been lowered in grade because of deterioration in circumference due to decay. The remaining 122, or 68 per cent, have deteriorated enough to require that they be classed at least one grade lower, and, of these, 45 must be classed at least two grades lower, while of a few the deterioration is even greater.

ANALYSIS OF PRESERVATIVES USED IN THE TREATMENT OF POLES SET IN THE AUGUSTA-SAVANNAH AND HELENA-MELDRIN LINES.[a]

Samples of the preservatives used for the treatment of experimental poles in the Augusta-Savannah and Helena-Meldrin lines were analyzed by the engineering department of the American Telephone and Telegraph Company. These analyses were made in

[a] Reprinted from Forest Service Circular 104, with names of preservatives added.

accordance with the company's methods for the analysis of creosote and carbolineum standard at the time these treatments were made (1905). The results of the analyses follow:

Preservative sold as Avenarius Carbolineum.[a]

	Series I.	Series II.
Color	Red-brown	Red-brown.
Specific gravity at 17° C.	1.121	1.122.
Mineral matter	0.160	0.050.
Flashing point	137° C.	137° C.
Burning point	164° C.	168° C.
Distillates:		
Below 235° C.	0.41 per cent	0.61 per cent.
Loss	0.19 per cent	0.22 per cent.
From 235° C. to 315° C.	19.16 per cent	26.97 per cent.
Residue above 315° C.	70.24 per cent	72.20 per cent.
Solids, 1.7° C. to 4.4° C.	No separation	No separation.
Tar acids	1.12 per cent	1.16 per cent.

[a] Manufacturers' analysis: Color, red-brown; specific gravity at 21° C., 1.126; viscosity at 21° C., 115.860; mineral matter (ash), 0.047 per cent; flashing point, 127° C.; burning point, 179° C.; distillates—from 220° C. to 260° C., 4.5 per cent; rom 260° C. to 274° C., 1 per cent; from 274° C. to 302° C., 20 per cent; naphthalene, very slight trace; mineral acids (HCl, H_2SO_4), very slight trace; phenols, very slight trace.

Preservative sold as S. P. F. Carbolineum.

	Series I.	Series II.
Color	Red-brown	Red-brown.
Specific gravity at 17° C.	1.134	1.134.
Flashing point	135° C.	135° C.
Burning point	163° C.	162° C.
Distillates:		
Below 235° C.	0.35 per cent	0.31 per cent.
Loss	0.13 per cent	0.19 per cent.
From 235° C. to 315° C.	28.84 per cent	30.10 per cent.
Residue over 315° C.	70.68 per cent	69.40 per cent.
Solids, 1.7° C. to 4.4° C.	No separation	No separation.
Tar acids	1.30 per cent	1.30 per cent.
Mineral matter	0.31 per cent	0.47 per cent.

Preservative sold as Spirittine.[a]

	Series I.	Series II.
Color	Green-black	Green-black.
Specific gravity at 17° C.	1.032	1.031.
Flashing point	90° C.	90° C.
Burning point	99° C.	101° C.
Distillates:		
Below 235° C.	15.14 per cent	14.97 per cent.
Loss	0.65 per cent	0.53 per cent.
From 235° C. to 315° C	26.23 per cent	25.60 per cent.
Residue above 315° C.	57.98 per cent	58.90 per cent.
Solids, 1.7° C. to 4.4° C.	No separation	No separation.
Tar acids	15.40 per cent	16.30 per cent.
Mineral matter	0.14 per cent	0.02 per cent.

[a] Manufacturers' analysis: Color, green-black; specific gravity, 1.03; flashing point, 78° C.; burning point, 93° C.; distillates—below 315° C., 37.40 per cent; above 315° C., 52.69 per cent; coke and gas corresponding to, 9.91 per cent.

Coal-tar creosote.

	Series I.	Series II.
Color	Greenish-brown	Greenish-brown.
Specific gravity at 38° C.	1.035	1.035.
Distillates:		
Below 170° C.	0.17 per cent	0.09 per cent.
From 170° C. to 205° C.	1.25 per cent	0.70 per cent.
From 205° C. to 210° C.	1.14 per cent	0.74 per cent.
From 210° C. to 235° C.	43.96 per cent	45.92 per cent.
From 235° C. to 240° C.	6.66 per cent	6.12 per cent.
From 240° C. to 270° C.	19.48 per cent	20.03 per cent.
From 270° C. to 300° C.	10.07 per cent	9.61 per cent.
Residue above 300° C.	17.00 per cent	16.30 per cent.
Loss	0.27 per cent	0.49 per cent.
Total	100.00 per cent	100.00 per cent.
Naphthalene	45.10 per cent	46.66 per cent.
Liquid at	38° C.	38° C.
Tar acids	9 c. c.	8.3 c. c.

Preservative sold as Imperial Wood Preservative.

	Series I.	Series II.
Color	Greenish-black	Greenish-black.
Specific gravity at 17° C.	1.035	1.035.
Flashing point	115° C.	111° C.
Burning point	129° C.	123° C.
Distillates:		
Below 235° C.	2.51 per cent	3.65 per cent.
Loss	0.29 per cent	0.51 per cent.
From 235° C. to 315° C.	26.00 per cent	24.74 per cent.
Residue at 315° C.	71.20 per cent	71.10 per cent.
Solids 1.7° C. to 4.4° C.	No separation	No separation.
Tar acids	13.70 per cent	11.80 per cent.
Mineral matter	0.04 per cent	

Preservative sold as Creolin.

	Series I.	Series II.
Color	Light brown	Light brown.
Specific gravity at 38° C.	1.007	1.005.
Distillates:		
Below 170° C.	26.66 per cent	96.90 per cent.
From 170° C. to 205° C.	17.39 per cent	0.10 per cent.
From 205° C. to 210° C.	9.27 per cent	
From 210° C. to 235° C.	25.92 per cent	
From 235° C. to 240° C. From 240° C. to 270° C. From 270° C. to 300° C.	15.98 per cent	0.15 per cent.
Above 300° C.	4.24 per cent	0.85 per cent.
Loss	0.54 per cent	2.00 per cent.
Total	100.00 per cent	100.00 per cent.
Naphthalene	35.19 per cent	None.
Water	20.00 per cent	90 per cent.
Tar acids	19 c. c.	1 c. c.
Note	Sticks and other foreign matter present.	Sticks, sand, and other foreign matter present.

DETAILED TABLES AND CURVES SHOWING RATE OF SEASONING OF POLES.

TABLE 27.—*Rate of seasoning of southern white cedar poles at Wilmington, N. C.* [a]

Duration of seasoning.	Spring cut.		Summer cut.		Autumn cut.		Winter cut.	
	Weight per cubic foot.	Moisture content.[b]	Weight per cubic foot.	Moisture content.[b]	Weight per cubic foot.	Moisture content.[b]	Weight per cubic foot.	Moisture content.[b]
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*
0	34.8	68	36.6	77	38.7	87	38.9	88
1	27.7	34	28.5	38	29.5	43	29.9	44
2	26.3	27	26.8	29	27.9	35	28.3	37
3	25.9	25	26.5	28	27.7	34	26.7	29
4	25.7	24	26.5	28	27.5	33	26.5	28
5	25.6	24	26.7	29	27.2	31	26.0	26
6	25.5	23	26.8	29	26.7	29	25.7	24
7	25.4	23	27.0	30	26.5	28	25.6	24
8	25.4	23	26.9	30	26.2	27	25.6	24
9	25.3	22	26.7	29	26.0	26	25.6	24
10	25.0	21	26.7	29	25.9	25	25.5	23
11	....	....	26.6	29	25.7	24	25.5	23
12	....	....	26.5	28	25.7	24	25.5	23
13	....	....	26.4	28	25.7	24	25.5	23
14	....	....	26.2	27	25.7	24	....	....
15	....	....	26.2	27	25.7	24	....	....
16	....	....	26.1	26	25.8	25	....	....
17	....	....	26.0	26	....	....	....	....

[a] Based on six hundred 25-foot and 30-foot poles. The average volume of 30-foot poles was 20.76 cubic feet, and of 25-foot poles, 14.53 feet.

[b] Dry weight, according to Sharpless (Vol. IX, Tenth Census), is 20.7 pounds per cubic foot.

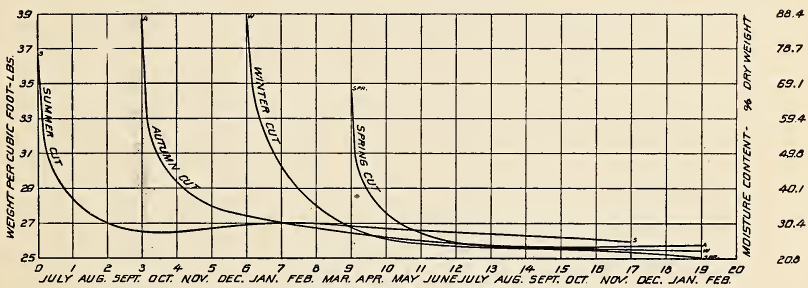

FIG. 7.—Rate of seasoning of southern white cedar poles, Wilmington, N. C.

TABLE 28.—*Rate of seasoning of chestnut poles at Pisgah, N. C.* [a]

Duration of seasoning.	Spring cut.		Summer cut.		Autumn cut.		Winter cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*
0	55.2	97	53.5	91	54.7	95	56.5	101
1	52.3	86	50.6	80	51.7	84	54.3	93
2	50.2	79	48.3	72	50.3	79	52.7	88
3	49.1	75	47.0	67	49.9	78	51.5	83
4	48.4	72	46.3	65	49.6	77	50.7	81
5	48.1	71	46.0	64	49.0	75	49.8	77
6	47.7	70	45.8	63	48.8	74	49.2	75
7	46.8	67	45.7	63	48.3	72	48.3	72
8	....	....	45.7	63	47.3	69	47.7	70
9	....	....	45.3	61	46.4	65	47.5	69
10	....	....	44.8	60	45.8	63	47.2	68
11	....	....	43.8	56	45.5	62	....	....
12	....	....	43.5	55	44.8	60	....	....
13	....	....	43.3	54	....	....	....	....
14	....	....	43.3	54	....	....	....	....
15	....	....	43.2	54	....	....	....	....

[a] Based on six hundred 25-foot and 30-foot poles. The average volume of 30-foot poles was 21.12 cubic feet, and of 25-foot poles 14.70 cubic feet.

TABLE 29.—*Rate of seasoning of chestnut poles at Dover, N. J.* [a]

Duration of seasoning.	Spring cut.		Summer cut.		Autumn cut.		Winter cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*
0	50.8	81	51.5	83	50.8	81	51.8	85
1	49.0	75	48.8	74	48.4	72	50.8	81
2	47.5	69	47.4	69	47.2	68	49.8	77
3	46.5	66	46.8	67	47.0	67	48.7	73
4	46.0	64	46.6	66	46.8	67	47.5	69
5	45.5	62	46.4	65	46.6	66	46.3	65
6	45.1	61	46.2	65	46.2	65	45.3	61
7	44.5	59	46.1	64	45.5	62	44.5	59
8	....	....	45.7	63	44.7	59	44.1	57
9	....	....	45.0	60	43.9	56	43.8	56
10	....	....	44.0	57	43.2	54	43.2	54
11	....	....	43.4	55	42.8	52	....	....
12	....	....	43.0	53	42.5	51	....	....
13	....	....	42.7	52	42.2	50	....	....
14	....	....	42.4	51	....	....	....	....

[a] Based on four hundred 30-foot poles. Volume, 22 cubic feet.

TABLE 30.—*Rate of seasoning of chestnut poles at Thorndale, Pa.*[a]

Duration of seasoning.	Spring cut (volume, 20 cubic feet).		Summer cut (volume, 21 cubic feet).		Autumn cut (volume, 20 cubic feet).		Winter cut (volume, 20 cubic feet)	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
0	53.0	89	54.0	92	52.7	88	52.9	88
1	50.1	78	50.1	78	50.5	80	51.7	84
2	47.9	71	48.2	72	49.3	76	50.4	80
3	46.4	65	47.4	69	48.8	74	49.1	75
4	45.4	62	47.1	68	48.6	73	47.6	70
5	44.8	60	46.8	67	47.9	71	46.3	65
6	44.4	58	46.7	66	46.9	67	45.1	61
7	43.9	56	46.4	65	45.7	63	44.3	58
8	43.6	55	46.1	64	44.8	60	43.6	55
9	43.6	55	45.7	63	44.1	57	42.9	53
10	43.6	55	45.2	61	43.8	56	42.4	51
11	42.4	51	44.7	59	43.2	54	42.0	50
12	43.0	53	44.2	57	42.5	51	41.8	49
13	42.5	51	43.7	56	41.8	49	41.6	48
14	42.3	51	43.3	54	41.6	48	41.5	48
15	42.1	50	42.9	53	41.7	49	41.5	48
17	41.8	49	42.5	51	41.9	49	41.5	48
19	41.5	48	42.3	51	41.8	49	....	....
20	41.3	47	42.1	50	42.2	50	....	....
21	41.0	46	41.7	49	....	....	....	....
23⅓	40.7	45	41.3	47	....	....	....	....

[a] Based on six hundred 30-foot poles.

TABLE 31.—*Rate of seasoning of chestnut poles at Parkton, Md.*[a]

Duration of seasoning.	Fall cut.		Winter cut.		Spring cut.		Summer cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
0	56.4	85.4	56.4	85.6	55.6	83.0	56.1	84.4
1	52.3	72.0	53.9	77.4	51.8	70.5	51.0	67.9
2	51.2	68.4	52.5	72.6	49.9	64.3	48.8	60.6
3	50.7	66.9	51.3	68.7	48.6	60.0	47.9	57.5
4	50.4	65.8	50.1	64.8	47.6	56.5	47.4	55.9
5	49.9	64.3	48.8	60.6	46.7	53.7	....	....
6	49.3	62.2	47.7	56.8	46.1	51.7	....	....
7	48.4	59.2	46.7	53.7	....	....	....	....
8	47.4	56.0	46.0	51.2	....	....	....	....
9	46.5	53.0	45.4	49.3	....	....	....	....
10	45.8	50.8	....	....	....	....	....	....
11	45.3	49.1	....	....	....	....	....	....
12	44.9	47.8	....	....	....	....	....	....

[a] Based on five hundred and fifty 30-foot poles. Oven dry weight, determined on disks cut from the poles, 30.4 pounds per cubic foot. Average volume, 20 cubic feet.

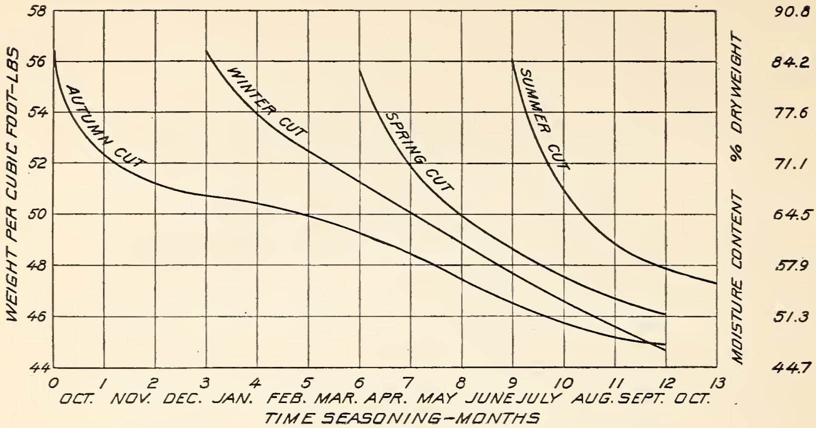

FIG. 8.—Rate of seasoning of chestnut poles, Parkton, Md.

TABLE 32.—*Rate of seasoning of northern white cedar poles at Escanaba, Mich.* [a]

Duration of seasoning.	Spring cut.		Summer cut.		Autumn cut.		Winter cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
0	31.9	77.4	32.7	81.7	32.2	79.0	34.2	90.0
1	27.7	53.8	29.1	61.4	....	....	....	....
2	26.9	49.7	27.3	51.9	....	....	....	....
3	26.7	48.4	26.8	49.1	....	....	33.6	86.4
4	....	....	....	....	....	....	27.5	53.0
5	....	....	....	....	31.9	77.2	25.6	42.3
6	....	....	....	....	25.7	43.0	24.8	37.5
7	....	....	....	....	24.0	33.2	24.2	34.3
8	....	....	26.6	48.0	23.2	29.0	....	....
9	....	....	25.3	40.5	22.9	27.2	....	....
10	....	....	24.4	35.7	....	....	....	....
11	26.0	44.2	23.9	32.9	....	....	....	....
12	24.5	36.0	23.5	30.7	....	....	....	....
13	24.1	33.7	....	....	....	....	....	....
14	23.8	32.3	....	....	....	....	....	....

[a] Based on 450 poles. Ovendry weight=18 pounds per cubic foot. Average volume, 17.62 cubic feet.

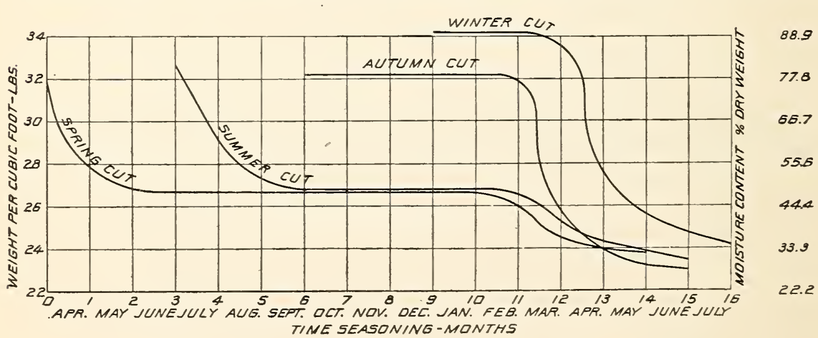

FIG. 9.—Rate of seasoning of northern white cedar poles, Escanaba, Mich.

TABLE 33.—*Rate of seasoning of western red cedar poles at Los Angeles, Cal.*[a]

Duration of seasoning.	Summer cut.		Fall cut.		Winter cut.		Spring cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*
0	[b] 42.4	133.0	[b] 42.4	133.0	[b] 42.4	133.0	[b] 42.4	133.0
1	....	....	....	....	....	....	....	....
2	....	....	....	....	....	....	....	....
3	....	....	....	....	....	....	[c] 38.12	109.5
4	....	....	....	....	[c] 36.12	98.5	33.0	81.3
5	....	....	....	....	28.25	55.2	31.0	70.3
6	[c] 32.5	78.6	....	....	26.30	44.5	29.3	61.0
7	31.1	70.9	[c] 33.0	81.3	25.30	39.0	28.0	53.8
8	30.0	64.8	29.0	59.3	....	....	....	....
9	28.5	56.6	26.5	45.6	....	....	....	....
10	26.5	45.6	25.5	40.1	....	....	....	....
11	25.0	37.4	....	....	....	....	....	....
12	23.5	29.1	....	....	....	....	....	....
13	23.46	28.9	....	....	....	....	....	....

[a] Based on four hundred 40-foot poles. The average volume of 300 poles was 27.34 cubic feet. Oven dry weight determined by sections cut from 12 poles, 18.2 pounds per cubic foot.
[b] Green weight based on weights of 25 summer cut poles taken immediately after cutting.
[c] Weight on arrival at Los Angeles, Cal., from three to seven months after cutting.

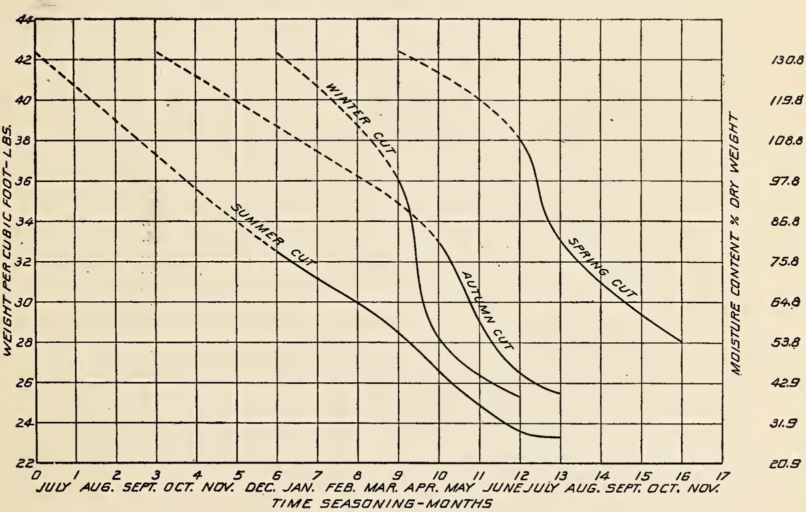

FIG. 10.—Rate of seasoning western red cedar poles, Los Angeles, Cal.

TABLE 34.—*Rate of seasoning of western yellow pine poles at North Fork, Madera County, Cal.*[a]

Duration of seasoning.	Autumn cut.		Winter cut.		Spring cut.		Summer cut.	
	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.	Weight per cubic foot.	Moisture content.
Months.	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*	*Pounds.*	*Per cent of dry weight.*
0	64.1	144.7	66.6	154.2	65.2	148.9	64.8	147.3
1	54.0	106.1	62.6	138.9	51.5	96.6	40.3	53.8
2	51.3	95.8	56.2	114.5	44.4	68.5	33.8	29.0
3	52.6	100.8	47.7	82.1	39.8	51.9	31.8	21.4
4	54.1	106.5	40.4	54.2	36.2	38.2	....	....
5	50.4	92.4	36.0	37.4	32.6	24.4	....	....
6	46.0	75.6	32.8	25.2	....	....	....	....
7	41.7	59.2	....	....	....	....	....	....
8	37.6	43.5	....	....	....	....	....	....
9	33.7	28.6	....	....	....	....	....	....
10	30.3	15.6	....	....	....	....	....	....

[a] Based on four hundred 40-foot poles. Oven dry weight, 26.2 pounds per cubic foot. Average volume 26.1 cubic feet.

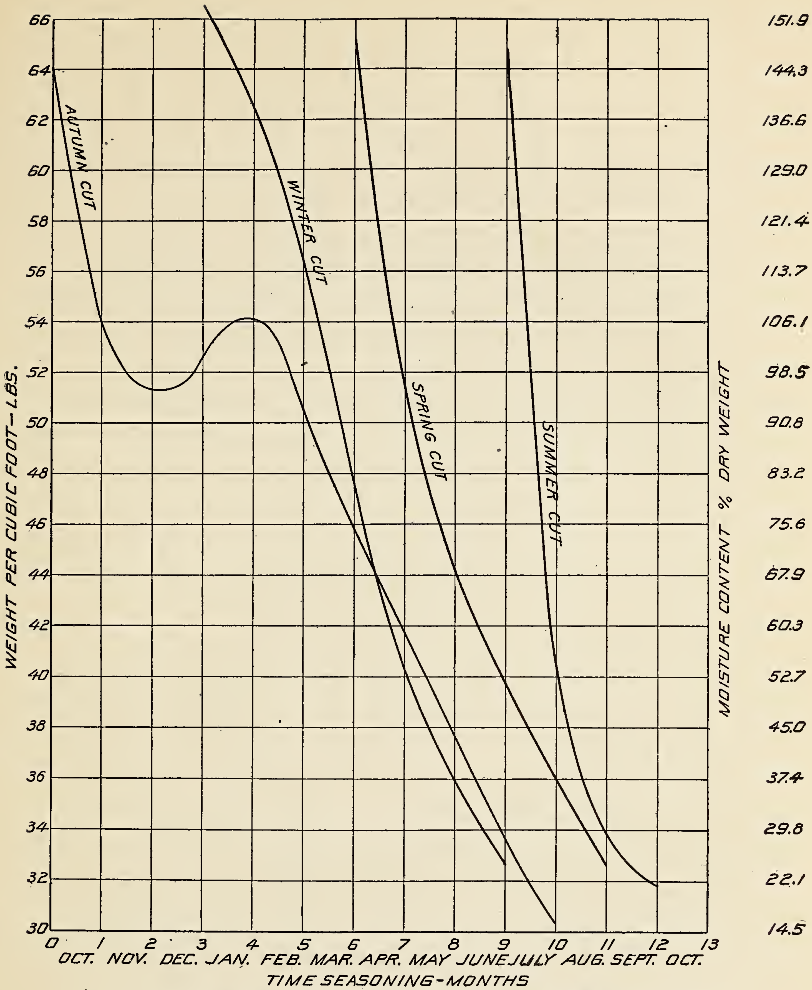

FIG. 11.—Rate of seasoning of western yellow pine poles, Madera County, Cal.

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